Intercellular Alkalizing Effects of the Naked Electron from Heliopatch

Magnesium is commonly understood as the free ions that are in water, many common supplements and foods. These ions are in the Mg^{2+} form and can be utilized by the body as an important nutrient. Magnesium is the fourth most abundant element in the body and is a cofactor in over 300 enzymes. Magnesium is also a neuromodulator and has many other roles. Recounting all of its functions here would be a document all its own, and many excellent reviews of the role for magnesium ions already exist. (Long & Romani, 2014)[1]

Magnesium ions are often accompanied by counter ions such as oxide (O^{-2}) or hydroxide (OH^-) which are alkalizing when ingested. An example is the antacid and laxative Milk of Magnesia, which contains magnesium hydroxide ($Mg(OH)_2$). These hydroxide or oxide counter ions can act directly to neutralize acidity (H^+) and therefore increase pH. This increase in pH is often referred to as alkalization and is widely considered a beneficial effect for performance of athletes. The mechanism is neutralization of acidity generated by muscles. These acids lead to a burning sensation and a fatigue of muscle and brain as pH drops below the physiological ideal.

While magnesium is an ideal source of alkalinity, the laxative effect of the ingested magnesium ion makes it impractical to use as an alkalizer for performance enhancement. This has led to the use of sodium bicarbonate ($NaHCO_3$) or potassium bicarbonate ($KHCO_3$), although these have their own problematic side effects.

Bicarbonate supplementation works, but suffers from many of the same drawbacks as other supplements taken orally. Chronic ingestion of bicarbonate may cause intravascular volume expansion with resultant hyporeninemia (low renin) and hypoaldosteronemia (low aldosterone) which dysregulates the water/salt balance in the body. Other side effects are gastrointestinal upsets such as vomiting and diarrhea (McNaughton, 1992)[2].

On a more horrifying note, oral administration of bicarbonate (HCO_3^-), has caused gastric rupture in at least 8 published case reports. Bicarbonate can cause excess carbon dioxide (CO_2) gas release when combined with gastric acid (HCl) and can lead to gastric rupture with a mortality rate as high as 65%. (Lazebnik N, 1986)[3].

$$KHCO_{3(aq)} + HCl_{(aq)} \rightarrow KCl_{(aq)} + H_2O_{(aq)} + CO_{2(g)} \text{ (pressure increase)}$$

[1] http://austinpublishinggroup.com/nutrition-food-sciences/fulltext/ajnfs-v2-id1051.php

[2] http://www.ncbi.nlm.nih.gov/pubmed/1331493

[3] http://www.ncbi.nlm.nih.gov/pubmed/3020119

Figure 1- Reaction of potassium bicarbonate with hydrochloric acid in the stomach. As a gas, carbon dioxide can create tremendous pressure within the stomach in a short time.

Obviously, stomach acid has a useful role as a component of the digestive process. Eliminating stomach acid leads to poor digestion of food, and can cause an increase in flatus within the digestive system as more of the nutrients in food are passed to the bacteria in the gut and their metabolic activities create gasses. Because pH in the body is more complex and compartmentalized than in a simple flask, there may be compensatory changes in the digestive system that do not benefit the athlete when they stop partaking of the bicarbonate solutions. Importantly, these drinks taste bad. This leads athletes to question their chosen lifestyle and causes displeasure and dissatisfaction among those who stay with it.

Gas in the digestive tract is definitely not performance enhancing and undigested food is undesirable; especially for athletes that need a large number of calories. Alkalinity in the digestive tract can cause poor absorption of many foods and supplements. In addition, alkaline blood can lead to slow elimination or accelerated removal of drugs from the body. Using such a broad mechanism to adjust the pH in the athlete's body creates a wide range of undesirable and undefinable outcomes.

Magnesium does not have a laxative effect when administered by routes other than ingestion. Magnesium is often given intravenously as water-soluble magnesium sulfate for chemotherapy patients with hypomagnesemia, but alkalizing particles of magnesium hydroxide or magnesium oxide are insoluble and cannot be administered by this method. This makes intravenous administration unsuitable as a method of administering the alkalizing magnesium hydroxide, oxide or carbonate.

A novel route of administration for alkalinity derived from magnesium is topical application of magnesium metal. This method is alkalizing, but in a way that does not involve the direct introduction of a hydroxide or bicarbonate. Instead, magnesium metal is placed upon the skin and corrodes. This electrochemistry releases naked electrons which transfer through the skin and penetrate deeply into the body's tissues, where free radicals are neutralized. An analogy would be like throwing a football to create the desired condition at a distance (a runner with a ball) rather than running with the football across the ground. The analogy of running with the ball is similar to an alkaline salt that is ingested and transfers from the digestive system through the circulatory system and to the target muscle.

Several possible reactions of the naked electron with radicals can occur, but all of these reactions share one common feature; an increase in pH.

Superoxide to Hydrogen Peroxide

The first reaction is the transformation of superoxide into hydrogen peroxide.

Superoxide is the first radical to be formed in the sequence of ROS after diatomic oxygen (O_2) has gained its first electron.

Likewise, superoxide can also be neutralized once it has been converted to hydrogen peroxide. The essential ingredients for this reaction are the superoxide radical, two molecules of acid (H^+) and two electrons.

$^{\bullet}O_2^- + 2H^+ + 2e^-$	$\rightarrow$	H_2O_2		+0.089V (inside the body)
$Mg_{(s)}$	$\rightarrow$	$Mg^{2+}_{(aq)} + 2e^-$		+2.37V (within the patch)
			=	+2.459 (short distance)

Figure 2- Half-cell reactions between superoxide and magnesium metal to form hydrogen peroxide and magnesium ions.

The reaction of superoxide with the naked electron is less likely to happen at a distance than the other reactions illustrated below due to its voltage. Fortunately, a class of enzymes called superoxide dismutase (SOD) is available within cells to help convert this radical to the more stable hydrogen peroxide. Hydrogen peroxide can then be converted by catalase or by the naked electron into a stable form.

Hydrogen Peroxide to Water

The reaction illustrated in figure 3 below illustrates the neutralization of hydrogen peroxide using two electrons and two molecules of acid (H^+).

$H_2O_{2(aq)} + 2H^+_{(aq)} + 2e^-$	$\rightarrow$	$2H_2O_{(l)}$		+1.77V (inside the body)
$Mg_{(s)}$	$\rightarrow$	$Mg^{2+}_{(aq)} + 2e^-$		+2.37V (within the patch)
			=	+4.14V (spontaneous > distance)

Figure 3- Half-cell reactions between hydrogen peroxide and magnesium metal to form water and magnesium ions.

This reaction in figure 3 consumes two molecules of acid (H^+), which increases pH. This consumption of acid leads to an alkalizing effect in the body wherever hydrogen peroxide is produced within the voltage multiplied by the resistance. This determines the “range” of the applied magnesium.

Hydroxyl to Hydroxide

Another radical that could be neutralized by the naked electron is the hydroxyl radical, one of the most damaging radicals in the body, and one for which there is no enzymatic defense.

$2OH^{\bullet}_{(aq)} + 2e^-$	$\rightarrow$	$2OH^-_{(aq)}$		+2.38V (inside the body)
$Mg_{(s)}$	$\rightarrow$	$Mg^{2+}_{(aq)} + 2e^-$		+2.37V (within the patch)
			=	+4.75V (spontaneous > distance)

Figure 4- Half-cell reactions between hydroxyl radicals and magnesium metal to form hydroxide and magnesium ions.

In the reaction above, the product of this neutralization of hydroxyl ($OH^{\bullet}$) radicals inside the body is hydroxide (OH^{-}). The relatively high voltage (>4V) from this reaction allows it to proceed spontaneously at a distance between the magnesium and the radicals inside the body. Hydroxide or its neutralization of acid to produce water is the essence of performance enhancing alkalization.

The action of the naked electron can be contrasted with the chemical antioxidants that need to travel within the body and actually contact the radical to neutralize it. One of the best studied and most comparable to the action of the naked electron is hydrogen gas (H_2).

Hydroxyl plus Molecular Hydrogen (H_2) to Make Water
H_2 is also known as elemental hydrogen or hydrogen gas. Hydrogen gas acts as an antioxidant, neutralizing hydroxyl radicals ($OH^{\bullet}$) and producing water (H_2O). Hydrogen is particularly useful as an antioxidant research tool because it penetrates all organs and neutralizes only hydroxyl radicals. It is difficult, however, to quantify the bioavailability of hydrogen because it can exit the body through the skin and the total absorbed by any route is difficult to measure.

$2OH^{\bullet}_{(aq)} + 2e^{-}$	$\rightarrow$	$2OH^{-}_{(aq)}$		+2.38V (inside the body)
$H_{2(g)}$	$\rightarrow$	$2H^{+}_{(aq)} + 2e^{-}$		0.0V (inside the body)
		$2H_2O$	=	+2.38V (short distance)

Figure 5- Half-cell reactions between hydroxyl radicals and hydrogen gas to form water.

The product of the reactions is hydroxide (OH^{-}) commonly known as base, and acid (H^{+}), which unite to form water spontaneously in the acid-base reaction.

$$2H^{+} + 2OH^{-} \rightarrow 2H_2O$$

Figure 6- Acid base neutralization reaction to form water.

The reaction of hydroxyl radicals with hydrogen gas will form water. This reaction occurs only upon collision of H_2 and $OH^{\bullet}$ and always will only form water (H_2O). There is no alkalizing effect from this reaction because hydrogen becomes acid and neutralizes the base made by the reduction of the hydroxyl radical to hydroxide.

Drinking hydrogen-rich water has been shown in numerous studies to decrease oxidative stress. In the following studies, the hydrogen enrichment is accomplished by placing magnesium metal in drinking water, and then drinking the resulting hydrogen-rich water. This water is also more alkaline due to the reactions of magnesium with the acid in the water to form hydrogen gas.

$2H^{+}_{(aq)} + 2e^{-}$	$\rightarrow$	$H_{2(g)}$		+0.0V (inside glass of water)
$Mg_{(s)}$	$\rightarrow$	$Mg^{2+}_{(aq)} + 2e^{-}$		+2.37V (on magnesium surface)
			=	+2.37V (spontaneous on contact)

Figure 7- Half-cell reactions between protons (acid) and magnesium metal to form hydrogen gas and magnesium ions.

The Heliopatch Solution

We have developed a new type of antioxidant supplementation at Heliopatch- direct electron donation with the naked electron. This system doesn't send an antioxidant into the body to deliver an electron. Instead, it connects a potent source of electrons to the skin and these are transmitted into the body to create an electrochemical cell. These naked electrons don't have a chemical carrier; they flow within the body's network of electrically conductive paths to the places where the free radicals are made. These electrons are attracted over the greatest distances to the most potent free radicals such as hydroxyl radicals ($OH^{\bullet}$).

The high innate voltage of this electrochemical reaction means that the anodic and cathodic reactions can occur at great distances from one another. Instead of requiring transport of the antioxidant through the bloodstream and adjacent to the free radical to be neutralized, the electrons can flow through tissues using electrically conductive routes that do not depend upon blood. When the free electron encounters the hydroxyl radical ($OH^{\bullet}$), it creates the benign hydroxide (OH^-) which increases pH; this alkalization provides a performance-enhancing effect of its own beyond the neutralization of the radical.

Hydroxyl Radicals, Hydroxide and the Alkalizing Effect

Hydroxide is considered by many to have positive effects on performance. It is known as an alkalizing effect, and alkaline substances have been used to enhance performance in athletics for many years. When the electrons flow into the person and attack a hydroxyl radical, this increases pH. Most metabolic processes result in acidic outputs such as CO_2 (aerobic) or lactic acid (anaerobic). When you exercise more than your oxygen delivery can keep up with, the body utilizes anaerobic metabolism. A product of this metabolic pathway is pyruvate, which becomes lactic acid; this acidity leads to the burning sensation in the muscle. This lactic acid then moves from the muscle to the blood, decreasing your blood pH.

Recent studies (Mueller SM, 2013)[4] showed significant performance enhancement where average cycling time-to-exhaustion (Tlim) increased by 23.5% with $NaHCO_3$ supplementation as compared to placebo. These results corroborate the performance enhancing results of ingesting sodium bicarbonate that have been observed since the seventies (Jones NL, 1977)[5]. In horse racing the use of buffering agents is banned, and limits have been set on the concentration of bicarbonate in blood samples taken before races (Gill, 2015)[6].

In many examples of medical conditions that cause acidosis, the alkalization of the body has beneficial impacts. The use of enough potassium bicarbonate in the diet to

[4] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3623762/
[5] http://www.ncbi.nlm.nih.gov/pubmed/24031
[6] http://www.equiforce.com/bicarbonate-loading-in-horses.aspx

neutralize the daily net acid load in postmenopausal women resulted in a significant increase in Insulin-like Growth Factor-1 (IGF-1). Low protein diets lead to a systemic decrease in many factors such as IGF-1; supplementation with bicarbonate increased the levels of IGF-1 from 95.9 ± 31.7 ng/ml to the same levels as the high protein group 136.4 ± 41.3 ng/ml, a statistically significant change of 40.5 ng/ml (Ceglia L, 2009)[7]. IGF-1 has many roles in the body; one well-documented role for this hormone is the anabolic increase in muscle mass (Velloso, 2008)[8].

Clearly, the benefits of alkalizing the blood for athletic performance are significant, but the means employed to produce this effect through oral supplementation can carry some unacceptable risks which are not justified by the increase in performance. If the alkalinity was increased without the production of carbon dioxide, there would be no interference with the body's normal signaling mechanisms. Likewise, without the evolution of CO_2 gas the gruesome prospect of gastric rupture would also be avoided.

Heliopatch generates alkalinity electrochemically and at a distance from the magnesium rather than through a direct ingestion and transport of an alkaline substance. Converting the dangerous hydroxyl radical ($OH^\bullet$) into hydroxide (OH^-) turns the harmful into something beneficial. This is all without oral supplementation, ingestion or the problematic production of gaseous CO_2.

Electrochemical Experiments with Alkalization

At Heliopatch, we have conducted a series of experiments to verify the increase in pH under controlled conditions at a distance from the magnesium metal corrosion, which creates its own increase in pH. Our experiments utilized long salt bridges filled with gel and potassium chloride to prevent the high pH in the magnesium containing solution from directly changing the pH of the target solutions that represent the body's chemistry as a target for electrons. These salt bridges allow the electrons to be the only pH modifier acting upon the solution. Each target solution contains a pH indicating dye as well as an electronic pH probe that detects the change in pH.

We used a variety of conditions to help illustrate the alkalizing nature of the electrons delivered by magnesium.

In the first solution is purified water and pH indicator dye plus an electrode donating electrons.
In a second solution is purified water and pH indicator dye with a drop of hydrogen peroxide plus an electrode donating electrons.
In a third solution is purified water and pH indicator dye a drop of hydrogen peroxide and iron sulfate plus an electrode donating electrons.
In a fourth solution is purified water and pH indicator dye plus iron sulfate.

[7] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2730228/
[8] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2439518/

Immediately upon addition of hydrogen peroxide to the iron sulfate solution in solution 3 the pH dropped dramatically and the Oxidation-Reduction Potential (ORP) increased, indicating the catalytic action of iron on the hydrogen peroxide.

The immediate reactions were to favor the formation of acid from hydrogen peroxide and iron (II). Once balance between iron (II) and iron (III) was achieved, we observed a steady increase in pH when electrodes were active within the solution of Fenton's reagent. The equations in figure 8 illustrate the reactions between iron and hydrogen peroxide in the same solution, the pH when considering just these reactions stays neutral because the two reactions of iron with hydrogen peroxide produce an equal amount of acid and base.

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^{\bullet} + OH^{-}$$

$$Fe^{3+} + H_2O_2 \rightarrow Fe^{2+} + O_2^{\bullet} + 2H^{+}$$

Figure 8- The reactions of the Fenton's Reagent upon hydrogen peroxide to generate hydroxyl radicals and superoxide.

However, in a solution that also contains an electrode that can donate free electrons as illustrated in figure 4, the hydroxyl radicals will be converted into hydroxide (OH^-) and increase pH. The same reactions occur within your body, where free iron interacts with the hydrogen peroxide made by superoxide dismutase and converts this into a hydroxyl radical ($OH^{\bullet}$) and superoxide. When a source of free electrons is nearby, such as the magnesium in Heliopatch, these reduce hydroxyl to make a hydroxide. This increases your body's pH and counters the effects of extreme physical exertion.

This new form of antioxidant, the naked electron, provides an unprecedented source of alkalinity that can penetrate deeply into your hardest working tissues irrespective of blood flow. This makes the naked electron as revolutionary for athletic performance and recovery as the advent of air transport was for logistics.

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