

Covering Your Nutritional Bases: The Importance of Acid-Base Balance

Contributed by Dr. John Berardi
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While I do my best try to stay abreast of the latest nutrition and supplement research, once in a while I find myself totally ignorant to an important topic or sound body of literature. Take, for example, creatine-monohydrate supplementation. At this year's American College of Sports Medicine annual meeting, I heard about this wonder supplement for the very first time. After asking several naïve questions, my embarrassed friends and colleagues informed me that creatine has been used for years and was perhaps the most popular ergogenic aid ever! In addition, I found out that at least 500 studies have been published, with over 70% of them demonstrating a positive effect. Go figure (scratching head)!

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<http://www.musculardevelopment.com/content/view/1401/182/>

It's
Out There But I'll Be Damned If I Can See It

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Alright, I'm just kidding about not knowing about creatine, but the fact remains; once in a while some important literature eludes my discriminating eye. You can't blame me, though. A search of Medline (PubMed.com), my favorite search engine for literature reviews, narrowed down to all abstracts published in the year 2003 with the keyword "nutrition," generates over 2,300 published papers. Now that's a lot of literature to sort through!

I See
The Light

The latest topic that I've remained fairly ignorant about until very recently is the strong relationship between food selection and the acid-base balance of the body. As many of you know, I lead the campaign against the old adage: "a calorie is a calorie." In fact, I've written an entire article on the topic entitled Lean Eatin'.

While my crusade has focused on proper food selections to enhance the thermic effect of feeding as well as the hormonal response to different foodstuffs, I've recently acquired a whole new weapon for my assault. You see, different foods - based on their digestibility, micronutrient composition, protein content, and a number of other factors - can lead to marked fluctuations in the acid-base status of the body. Since many of you are probably wondering what this has got to do with looking good naked, I encourage you to read on and find out how the acid-base balance of the body is critical to your health, your body composition, and even your exercise performance. Furthermore, find out how a few simple food substitutions and/or a few inexpensive supplement additions can correct your acid-base woes.

Before I get down to it however, I've got to give credit where credit is due. I can't assume full responsibility for stumbling across this fascinating line of research. It was actually a fellow researcher and nutrition colleague, Dr. Loren Cordain (of Paleo Diet fame) who pointed me in this direction during a recent "roundtable" we did together. So, if after you've read this article you feel compelled to thank someone for the great information, give him a shout at PaleoDiet.com (and then you can feel free to praise me at JohnBerardi.com).

Acid-Base
Nutrition Basics

When a food is ingested, digested, and absorbed, each component of that food will present itself to the kidneys as either an acid-forming compound or a base-forming one. And when the sum total of all the acid producing and the base producing micro and macronutrients is tabulated (at the end of a meal or at the end of a day), we're left with a calculated acid-base load. If the diet provides more acidic components, it will obviously manifest as a net-acid load on the body. And if it provides more basic components, it will obviously manifest as a net-base load on the body.

In the past, scientists have looked for various techniques to try to quantify whether a food is acid producing or base producing. One method that was commonly used was ash analysis. Using this technique, a food would be combusted and the ash would be analyzed to determine how much of the food was alkaline and how much was acid. When examining the micronutrients present in many foods we see that:

Acidic anions in food include chloride, phosphorous, sulfates, and other organic acids.

Basic/Alkaline cations in food include sodium, potassium, calcium, and magnesium.

The ash analysis technique has its limitations, though. Since simple food/ash analysis doesn't take into account bioavailability of the nutrients in a given food, the acid-base balance of the body after consuming specific foods doesn't often match the acid or base-producing estimate generated from the ash analysis. In other words, the ash analysis ain't all that effective.

Recognizing this limitation, Remer and Manz developed food-rating values that they refer to as PRAL (potential renal acid load) and the NAE (net acid excretion).(1) The NAE can be determined directly by measuring the acid and the ammonium appearing in the urine and then subtracting out the measured urinary bicarbonate. This method yields a net acid excretion score based on direct measurements of the urine. This score, however, reflects total acid and base load of a mixed diet and not the acid or base load of the individual foods in the diet.

To more

accurately predict the acid or base potential of a given food, another technique is needed. Unlike the aforementioned technique, the NAE can be determined indirectly by adding up all the urinary acidic anions from the above method and subtracting out the basic/alkaline cations described above. Since the urinary anion and cation excretion is directly related to food intake, it's possible to approximate net acid or base load from the composition of the food. This net acid or base load is called the PRAL (potential renal acid load).

Therefore, in taking into account the composition of the food, the bioavailability of the different micro and macronutrients (especially protein) of the food, the sulfur content of the food, and the obligatory diet-independent organic acid losses, it's then possible to estimate a physiologically meaningful index of the acid or base load based on the food consumed (PRAL).

For those of you who don't really care about PRALs and NAEs, here's the one sentence summary of what I'm talking about. In layman's terms, researchers can now analyze a food and based on its components, determine what the true acid or base load on the body will be. If you're still wondering why this is important, read on.

Why Acid Is Bad

Every cell of the body functions optimally within a certain pH range (pH is a measure of the acidity or alkalinity of the body). In different cells, this optimal range is different, however, the net pH of the body has to remain tightly regulated. One common problem with most industrialized societies is that our diets produce what's called a "low grade chronic metabolic acidosis." In other words, the PRAL of our diets is high and this means that we're chronically in a state of high acidity. While there are a number of disease states that induce severe metabolic acidosis, we're talking a sub-clinical rise in acidity here. Therefore, your doc probably won't notice the problem. But that doesn't mean that you're in the clear. Your cells will recognize the problem.

So what's wrong with this low-grade chronic metabolic acidosis? Well, since the body must, at all costs, operate at a stable pH, any dietary acid load has to be neutralized by one of a number of homeostatic base-producing mechanisms. So, although the pH of the body is maintained and your doctor visits turn out fine, many cells of the body will suffer. Here are some of the most severe consequences of your body's attempt to maintain a constant pH in the face of an acidic environment:

Hypercalciuria (high concentrations of calcium in the urine). Since calcium is a strong base and bone contains the body's largest calcium store, metabolic acidosis causes a release in calcium from bone. As a result, osteoclastic (bone degrading) activity increases and osteoblastic (bone building) activity decreases. The net result of these changes is that bone is lost in order to neutralize the acidic environment of the body. The calcium that was stored in the bone is then lost in the urine along with the acid it was mobilized to neutralize. This creates a negative calcium balance (more calcium is lost from the body than is consumed) and bones get weak. (2,3,4,6)

Negative nitrogen balance (high concentrations of nitrogen in urine). Glutamine is responsible for binding hydrogen ions to form ammonium. Since hydrogen ions are acidic, glutamine acts much like calcium to neutralize the body's acidosis. Since skeletal muscle contains the body's largest glutamine store, metabolic acidosis causes muscle breakdown to liberate glutamine from the muscle. The amino acids from this muscle breakdown are then excreted, causing a net loss of muscle protein. (2,7)

In addition to bone and muscle loss, other consequences of acidosis include:

Decreased IGF1 activity (4)

GH resistance (4)

Mild hypothyroidism (4)

Hypercortisolemia (4,5)

Interestingly, low-grade metabolic acidosis seems to worsen with age. Many have speculated that this is due to an age-related decline in kidney function (and acid excretion). Of course, osteoporosis and muscle wasting are unfortunate consequences of aging. While it's too early to tell, perhaps some of the bone and muscle loss evident as individuals get older is a result of diet-induced acidosis. This means that employing a few simple acid-base strategies may help slow osteoporosis and sarcopenia.

Recently, Sebastian and colleagues compared the pre-agricultural diet of our ancestors to the modern North American diet.(8) After evaluating the two diets for what they call NEAP (net endogenous acid production) - essentially the same measure as the PRAL above - a -88mEq/day acid load characterized the pre-agricultural diet while the modern diet was characterized by a +48mEq/day acid load. What this means is that our ancestors evolved eating a diet that was very alkaline/basic and therefore very low acid. However, modern people are eating a diet that is high in acid, and therefore very different from what we evolved to eat. As a result, our modern diet is responsible for what the authors have called a "life-long, low grade pathogenically significant systemic acidosis."

How have we gotten so far off track? Well, the shift from net base producing foods to net acid producing foods comes mostly as a result of displacing the high bicarbonate-yielding plants and fruits in the diet with high acid grains. In addition, most of our modern energy dense, nutrient poor selections are also acid forming. Finally, high protein animal foods tend to be acid producing as well.

If you're now wondering how your diet stacks up, check out the table I've provided below. This table includes a listing of 114 commonly consumed foods and their PRAL scores. A negative PRAL score indicates the food is basic/alkaline. A positive PRAL score indicates the food is acidic. A score of 0 indicates the food is neutral.

I'm
Here To Straighten Out Your Acids

After perusing this list it should be apparent that both the typical modern diet as well as the typical athletic diet is suspect. After all, even a high protein diet rich in clean, whole grain carbs will produce a net acid load. Since a neutralization of the Western diet without a change in energy intake or macronutrient composition has been shown to improve bone health, to shift nitrogen balance from negative to positive, to reduce blood cortisol concentrations, to increase thyroid hormone production, and to reverse the GH resistance discussed above, it's important that athletes take the appropriate steps to shift their diets away from that low grade chronic metabolic acidosis we discussed earlier. Here are some steps for accomplishing this goal:

Use the chart above to calculate a PRAL score for each meal. To do this, you simply record the amount (in grams) of each food you eat in a meal. Then, multiply the PRAL score listed by your food amount. For example, if you've eaten 250g of lean meat (8 oz or about 1/2 lb), your PRAL score for the meat will be 7.8 (score for 100g) multiplied by 2.5 (for the 250g serving), or 19.5. If you've also eaten 250g of potato (8 oz or 1/2lb), your PRAL score for the potato is -4 (score for 100g) multiplied by 2.5 (for the 250g serving) or -10. In addition, if you've eaten 100g of spinach, the PRAL score for the spinach is -14. If you tally up the total score of this meal, the net PRAL is 19.5 (meat), -10 (potato), -14 (spinach), or -4.5. This means a meal containing 8 oz of lean meat, 8 oz of potato, and 3.5 oz of spinach produces a PRAL of -4.5. In other words, the meal produces a net alkalinity. That's what we're looking for.

After calculating the base or acid potential of the meal, add more vegetables regardless of the final tally. Everyone can always benefit from more vegetables in the diet. Many bone specialists are now recognizing that the most effective way to improve bone health is to eat lots of fruits and vegetables.(3)

If you're eating a big meal that's going to be a net acid producer and don't want to add more basic foods, consider adding a small amount of glutamine to this meal. Exogenous glutamine supplementation has been shown to neutralize acidosis.(7)

A cheaper alternative to glutamine supplementation is either sodium or potassium bicarbonate supplementation. You can add sodium bicarbonate (in the form of baking soda) to your beverages including your protein shakes, which probably are a bit on the acidic side (see milk above). A small 2-5g dose of baking soda would be sufficient to neutralize the shake. An alternative to baking soda is alka-seltzer.

Adding sodium to foods can increase the base potential and reduce the acidity of the meal.

A Few Additional Protein Notes

Many doctors, dietitians, and sports nutritionists have come down on animal protein for several reasons including its effect on renal acid load. While it's true that animal protein (especially animal flesh) does produce a high PRAL, I find it interesting that the same "experts" espouse high grain diets. As you can see from the charts above, whole grains are also very acid forming.

Another

interesting fact is that while a high protein diet is acid forming, the high protein diet also seems to counteract some of its own acid loading potential.(9) In other words, while protein produces an acid load, it also increases the body's capacity for excreting those acids. None of the other acid producing foods are as effective as protein in doing so. Besides, just like with the other acid-forming foods, all you have to do is consume enough basic foods and supplements to neutralize the acidity.

Conclusions

Just because

very few individuals in the sports-nutrition world are talking about acid-base balance doesn't mean that it's not important. Employing a few simple strategies to neutralize your high-acid diet may mean the difference between chronic low-grade acidosis - and the associated muscle wasting, bone loss, and altered hormonal profile - and a healthy, alkaline diet.

References

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For more information about acid/base balance please visit Dr. Berardi's page at:

<http://www.precisionnutrition.com/acid-base>

Attached is also the link to read the study recently published by Dr. Berardi:

Plant Based Dietary Supplement Increases Urinary
pH <http://www.jissn.com/content/5/1/20>

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