Micronutrients: Copper

Transcript

All right. We are here for our micronutrients module, copper section. Copper is one of those minerals that we don't talk too much about. It's not one of the sexy one like magnesium and zinc and calcium which get a lot of the press but it does get a fair amount of press. A lot of times it gets negative press in its ability to interfere with zinc. But let's talk about it. We also get some negative in terms of copper toxicity and pipes and things like that. Let's take a look at it and let's see it.

It's an important mineral and it has some definite functions in the human body. All of this stuff is not intended to replace a one on one relationship with a qualified health care professional and it's not medically advised. When you're working with people, just make sure that they know that you're giving them some education about how they can restore balance to their body. You're not telling them how they can cure or treat a disease. Let's look at copper.

Copper is an essential trace element. It's not needed in large amounts. It's found in the body in either the Cuprous form, it's Cu1+ or the Cupric which is Cu2+4. Most of it is in the Cu2+4. It can easily accept or donate electrons. That means that it's important for redox reactions, oxidation and reduction and in scavenging free radicals. We know we often think about copper as an antioxidant. It's not referred to in a lot of the literature as an antioxidant.

But indeed, anything that has the ability to participate in redox reactions scavenges free radicals because it can accept or donate so it can go either way. Hippocrates is said to have prescribed copper compounds to treat diseases as early as 400 BC. It's not new to our modern world to be working with different kinds of conditions nutritionally.

Let's take a look at the digestion and absorption of copper. What you're seeing on the right hand side, the picture, is the enterocyte which is a cell that lines the gut. You've got the microvilli, the villi and the microvilli on it, it's the absorptive surfaces. Copper is bound to Amino acid which is very common for minerals to be either in foods or also in their supplement forms. You see aspartate forms and citrate forms and all sorts of different forms. Actually, citrate is not an Amino acid but they're bound to Amino acid, it's the most common.

It needs HCL and pepsin to break it down. Obviously that's really important to get the mineral away from the Amino acid carrier. Proteolytic enzymes in the small intestine will further hydralize it. Then we have passive diffusion in the small intestine, mainly in the duodenum whenever we have high concentrations of copper.

If somebody's taking in a lot of copper in their food or in a supplement, then it's going to passively diffuse from the small intestine into the bloodstream, mainly in the duodenum, so it doesn't even have to go all way down to the ileum.

When there's lower concentrations of copper, it's got to be actively transported across a gradient just the way it's worded. Usually over 50% of it is absorbed. It's not like you're losing most of it. Most minerals are not going to be 100% absorbed. Most nutrients are not going to be 100% absorbed because there's so much that goes into interfering with it. We'll talk about some of those interfering factors as well.

There's certain things that enhance copper absorption. There are certain things that inhibit copper absorption. Let's take a look at them. There's three Amino acids that help the copper to get absorbed across the intestinal lumen through the enterocyte and into the bloodstream. Those are histidine, cysteine and methionine. There are also some organic acids that help it get absorbed. Citric, gluconic, lactic, acidic and malic.

Just as in the side, when we have various minerals, you have the form of a mineral, you may say, "Well, which form should I take of a mineral?" Your clients are going to ask you that a lot. "Should I take calcium citric, calcium malate?" Those are organic acids they're bound to. Or magnesium taurate, magnesium glycinate. Those are Amino acids that they're bound to. Just wanted to make sure I pointed that out to you.

These are guys that help the copper absorption, histidine, cysteine and methionine. On the organic acid side, citric, gluconic, lactic, acidic and malic. There's also things that inhibit copper absorption. Phytates, also known as phytic acid which is found in some grains. A lot of grains contain phytic acid which binds the copper and other minerals, by the way, and drags it out of the body.

Here's where the copper zinc interaction comes into play. When you get somebody supplementing more than 40 milligrams a day, the zinc must be supplemented along with copper. Some people and some studies have shown as little as 18 milligrams a day of zinc causes copper excretion or it inhibits the absorption. Whenever you're doing zinc, I would say in any decent amount other than the little bit that's in the multi, you want to make sure that you're taking copper or letting people know to take copper.

Large quantities of iron. Now, what are large quantities of iron? Studies didn't exactly say but my guess is large quantities of iron would be the kinds of amounts that are recommended in pregnancy or severe anemia. I've seen people get prescribed like 325 milligrams of iron. That's considered a large amount. The RDA is somewhere between 15 and 20 of iron, I would say anything above the RDA, you might want to be thinking about putting some extra copper in there.

Molybdenum doesn't seem to be gradient dependent. Again, if you're giving individual nutrients, you don't want to give the person at the same time as you give them molybdenum, same things to any of these. It's best if you don't give them together. You give them separate, calcium as glucorate, high doses like super high doses that most people don't take. Same as phosphorus, 2442 milligrams as glycerol phosphate or 2382 as calcium d-glucarate. That's very large. Most people don't take that much. Most people supplement calcium in the range of about 1000. Then large doses of vitamin C.

When in doubt, add it in. That's why taking some kind of multimineral supplement, I often recommend some people get a liquid multimineral supplement that folic acid to help with the absorption to just as an insurance policy especially when you're supplementing individual ones that they are deficient in so you can avoid this.

What does copper do? Well, there's enzymes called cuproenzymes. These cuproenzymes help in the formation of bone, hemoglobin and red blood cells. It works in balance with zinc and vitamin C to form something called elastin which is an important protein in the skin that keeps the skin elastic. As we age, the skin gets less elastic. It's less elastin being formed. Copper could be something that could be helpful here.

It's involved in the healing process, say bones and muscles and injuries. It's important in the Kreb cycle for energy production. Copper actually plays a role in hair and skin coloring. It's important for taste sensitivity. We know that zinc is also important for taste sensitivity. It's required for healthy nerves and joints and for the formation of collagen.

Let's talk about copper in energy production. A copper dependent enzyme called cytochrome C-oxidase plays a critical role in the cellular energy product. It catalyzes, it means that it accentuates, accelerates the reduction of the molecular oxygen to water. Cytochrome C-oxidase also generates an electron gradient that's used by mitochondria to create ATP, which is the energy currency of every cell.

What about copper and connective tissue? Well, the enzyme is called lysyl oxidase. It's required for the cross linking of collagen and elastin, the fibers need to be cross linked together. The lysyl oxidase, a copper dependent enzyme, is important for that. This makes it important for the formation of strong but flexible connective tissue. We don't want stiff connective tissue. We also don't want loose connective tissue where we have joints that just wobble all over the place.

Lysyl oxidase also maintains the integrity of connective tissue in the heart and blood vessels. It's not just in the muscular system where the tissue, it's in these in vital organs. It's also important in bone formation. There are a lot of nutrients involved in bone formation. It's not just about calcium.

Let's take a look about copper and iron. The copper oxides and ferro oxides. There's two different sets of oxidases. Ferrous iron which is Fe2+ to ferric iron, Fe3+ is a form of iron that can be loaded into iron carrying protein transfer for the blood cell formation. The opposite is what happens when we're taking the ferric iron which is the circulating form and we want to store it into ferritin and that's stored back as the ferrous iron in the storage.

Ceruloplasmin is the way that ... it's a protein that carries copper around the bloodstream. 90% of the copper in the bloodstream is going to be carried by ceruloplasmin. There's membrane bound ceruloplasmin which is in the membranes of the cells. Then there's two other proteins called hephaestin and zyklopen. I cannot say foreign names at all. Sorry about that. They're found in the intestine and the placenta.

When you don't have enough ceruloplasm, you can end up getting iron overload in the liver, brain and retina, because what happens, the oxidases, the copper oxidases are required to pull that out of storage and store it back. The iron mobilization from storage sites is impaired in copper deficiency. Think about it this way, if you look at somebody and you see that their ferritin is really high, and their circulating iron is low, it's possible that they have a copper deficiency. The ferro oxidase of ceruloplasm is essential to the flux of iron in the body. Copper and iron are really, really important to have in balance with each other.

Let's look at copper and the central nervous system. Remember dopamine? One of our neurotransmitters, one of inhibitory transmitters. It's an important function in the brain for keeping people calm and keeping them from going into depression. The dopamine beta hydroxylase is a copper dependent enzyme. It converts from dopamine to norepinephrine. Remember norepinephrine, what is that? It's adrenaline. It's important for the fight, flight response, the sympathetic nervous system.

The other thing is that it's really super important and more and more we're seeing disease of myelin formation, so this is important to know, that the myelin sheet is made up of phospholipids and the synthesis of those phospholipids is dependent of cytochrome C-oxidase activity. It's really critical that you're looking and making sure that your people who have MS or MS-like symptoms are sufficient in copper.

Copper is important for pigmentation. There is an enzyme called tyrosinase and it's required for the formation of melanin. Melanin is the pigment in the skin. Tyrosinase is formed in the melanocytes. Melanin plays a role in, of course, pigmentation. Your eyes, your skin, your hair. Pigmentation. I would expect that perhaps depigmentation diseases might have something to do with copper. If you're looking at people who are losing pigmentation in certain areas, you might consider looking for copper deficiency.

Here's another one and this is super important. One of the most important antioxidants in the body, I would say second only to glutathione, is superoxide dismutase.

It's a copper dependent enzyme. It catalyzes. Superoxide dismutase is a copper dependent enzyme. Catalyzes the conversion of superoxide radicals. These are really free radicals, very damaging, making them into hydrogen peroxide. It can be reduced, then to water, by other antioxidants, so you have the cycle that's going on, that's constantly going on in the body of oxidation and reduction. There's two forms of SOD that contain copper. There's a copper zinc SOD, which is found within most cells of the body including the red blood cells, and then there's extracellular SOD that's just depending on copper that's found in the lungs and the plasma.

Zinc can be important for the red blood cell superoxide dismutase, for protecting the red blood cells from oxidation. This is really important, and so even though copper is not considered one of the heavy hitters of the top minerals that the lay people know about, it's an important mineral. It has some really important function. Superoxide dismutase is serious stuff.

Ceruloplasmin, as we said before, is the copper carrying the molecule. It prevents free copper irons, copper irons that are free, that are not bound to the ceruloplasmin, can cause oxidative damage. The ceruloplasmin carries the copper around. The free copper and ions are powerful catalyst of free radical damage, so ceruloplasmin is super important.

The ceruloplasmin has the function, as we talked about earlier, for ferroxidase activity. The oxidation of the ferrous iron. Facilitate loading the iron into the transport protein. We need to have the ceruloplasmin to be able to take the iron out of storage and put it on the transfer protein to be carried about. It can prevent the free iron ions Fe2+ from participating in the free radicals.

It's really really important that we have good levels of copper to prevent anemia. A deficiency of copper can lead to an anemia. Or an anemia that looks strange in that the storage of the ferritin stores are high relative to the iron in the serum. Let's look at gene expression. Cellular copper levels enhance or inhibit the transcription of specific genes. The transcription is when the genes are activated and synthesized protein, so copper is important in the synthesis of certain proteins in the body.

It can regulate the expressions of genes by increasing the level of intracellular oxidative stress. A number of these signal transaction pathways are activated in response to oxidative stress. What that mean is that we talked about genetics and epigenetic expression, and sometimes these genes are turned on by oxidative stress. Like the body needs more of the specific reaction and it's turned on by the oxidative stress.

When we have this regulation, this over regulation or under regulation of gene expression it can affect detoxification, specifically of the reactive oxygen species. You basically think of the body as constantly subject to being rusted on the inside. If things get rusted when you leave something out ...

Metals out in the rain and in the oxygen and it gets wet and they turn rusty, that's oxidation. That's what happens inside the body. It's pretty graphic way to look at it. That's what happens inside the body when free radical damage is happening. It's really important to have these free radical molecules happening in a good amount.

Again, let's look at copper and iron. An adequate copper and nutritional status is necessary for the normal iron and metabolism of the red blood cell formation. Ceruloplasmin is required for iron transport to the bone marrow for red blood cell formation. Now we're talking about it being important for the red blood cell formation. Not just for the oxygen carrying capacity of the red blood cells but for the red blood cell formation.

Anemia can be copper deficiency. A lot of times we just go looking for iron deficiency, B12 deficiency, folic deficiency, but copper can be involve and that may be the missing link when people say, "I just keep taking iron supplements and nothing seems to help bring my iron levels up." You want to be looking at copper when you hear that in a patient's history.

If you take in too much iron, like we said earlier, if somebody is taking really like a high dose iron because they have a deficiency or they're pregnant, that can interfere with copper absorption, so you have to make sure that you're not giving them together and that you give extra copper to make up for that.

Let's take a look at copper and zinc. Well, taking zinc of more than 50 mg a day for an extended period of time can result in copper deficiency, but like I said earlier, it can also result from lower levels of zinc for long period of times. It's been shown a minimum of 18.5 milligrams. There is a particular intestinal cell protein in the wall of the intestine, inside the enterocytes called metallothionein, and it binds metals and prevent the absorption by trapping them in the intestinal cells, like in the cells. They don't go to the blood stream, they come from the blood and they're trapped in there and hopefully detoxify, because that's the intention.

But it has a stronger affinity for copper than for zinc. If you have high levels of metallothionein induced by taking a lot of zinc, it's going to cause a decrease in the copper absorption. Because when you have a lot of zinc it causes more of these metallothionein to be induced, to be created and then they then bind up the copper. Even though you have a lot of zinc you're not binding up the zinc, you're binding up more of the copper.

Let's look at vitamin C. Vitamin C can increase the absorption of copper. It reduces copper from the 2+ to the 1+ form. Vitamin C supplementation, 1500 milligrams a day for two months results in a significant decline in ceruloplasmin oxidative activity. How many people do you know that are taking more than 1500 milligrams a day of vitamin C? Lots. It's important that we're well rounded in the nutrition. That we're either making sure that they eat high copper foods or take a copper supplement if necessary.

Even supplements as low as 605 milligrams a day for three weeks resulted in decrease of ceruloplasmin oxidative activity. Neither of those studies found vitamin C supplementation to adversely affect copper and nutritional status. Even though they interfere with the ceruloplasmin we didn't see copper levels going down. How do you know if somebody has a copper deficiency? Where do they happen? What is the prevalence?

Low birth weight in infants and young children. It isn't common but it does happen. That's where it most likely happens. In cases of sever copper deficiency their ceruloplasmin levels may fall at 30% of normal, so that's going to affect what, that iron, right? The release of iron from stores. Hypocupremia, which is deficient copper is observed in certain genetic disorders of copper metabolism. There's one called aceruloplasminemia, and also Wilson's disease.

In Wilson's disease we're binding up the copper ... We're having a copper excess in the liver and it can affect the liver and liver functions. Let's look at the most common signs of copper deficiency. Anemia, that's unresponsive to iron but then it gets corrected by copper. You're probably going to see a lot of folks with anemia that's not responsive to iron. People are taking iron, taking iron, taking iron and nothing happens. You'll see them with low white blood cells in the neutrophils, so neutropenia.

We know that white blood cells are the first line of defense in the immune system, so neutrophils are often related to bacteria. If we have abnormally low numbers of neutrophils we may be compromising the immune system in terms of its ability to get rid of the bacteria, which increases its susceptibility to infection. Other signs, what we talked about it as being involved in the pigmentation, and known information. Loss of pigmentation, neurological symptoms and impaired growth. The impaired growth is the less common symptom but it still can happen theoretically anyway. We have osteoporosis, another abnormalities in bone formation, and finally it can affect cardiovascular function and it's probably related to the circulation.

Who's at risk? The high risk individuals happen to be infants and children that are only fed cow's milk formula. Premature instincts, especially low birth weight. Infants that have prolong diarrhea and infants and children recovering from malnutrition. That's the highest risk, so it really compromise children and infants. Other people that are at risk are people with malabsorption syndrome, like celiac, like sprue, like short bowel syndrome due to surgery.

I would guess also, I would add crohn's disease to that as well, because that can affect absorption if it's in the small intestine. Crohn's disease in the large intestine isn't going to affect it but crohn's disease can be throughout. People with cystic fibrosis are at a higher risk of copper deficiency. People who are on IV total parenteral nutrition, also known as TPN, basically they're not getting any nutrients, they are relying on the formula that's been given to them in the hospital and a lot of this do lack copper. Excessive zinc, over 50 milligrams a day. When in doubt you supplement or you let people know where to get high copper foods.

Let's look at acquired copper deficiency, as opposed to a genetic copper deficiency. You can get a neurologic syndrome that includes a central nervous system demyelination, a polyneuropathy, means neuropathy in multiple areas, multiple limps. Mayopathy, it's relating to the muscles. Inflammation of the optic nerve. This sounds a little bit like diabetes complications, doesn't it? We have some neuropathies, we have some problems with the eyes, it can look like a diabetic complication.

There's a ... When we look at the intestines and it's increased, it may suggest a malabsorption and you're like Menkes, that's a disease that's related to copper absorption. When we replace two milligrams a day of copper it normalized the copper and ceruloplasmin concentration, it stabilizes this condition and it significantly improves the quality of life. It's not much, 2 milligrams a day of copper.

This is an acquired disease, this is not an inborn or metabolism. This is something that people come up with for whatever reason their copper is low. It could be because of excess zinc for long periods of time, it could be because of an absorption problem, it could be because of taking in a lot of the things that are interfering, and it could be a lack of dietary copper.

In inherited copper deficiency is something called Menkes disease and occipital horn syndrome. There is mutations in the ATP7A gene, I haven't looked at that one up in 23and Me either. Because you know when people have this disease it's not like it's something you're going to find out via 23andMe. It impairs the transport intracellular copper, so the ability of the copper to be transported between cells.

It causes an accumulation in the cytosol of enterocytes and vascular endothelial cells, enterocytes sites are your lining cells and vascular endothelial cells are the that line the blood cells. Forgive me for repeating those things but some of this is new to some folks and the more you here it you go, yeah, enterocytes, I know what those are now. As oppose to going, oh yeah, I forgot, what are enterocytes.

These mutations can result in systemic copper deficiency and decrease cuproenzymes. All those different enzymes you talked about, including SOD, they're going to be deficient in someone who has this gene mutation. It affects a lot of stuff. It affects the copper accumulation in the blood brain barrier, so the transport of copper is affected. It affects the neurons and some of the symptoms would be seizures, connected tissue disorders, subdural haemorrhage, hair abnormalities like kinky hair. If you have kinky hair don't go thinking you have this disease, probably not.

On the occipital horn syndrome people have muscular hypotomia, low muscle tone, connective tissue abnormalities and problems with the occipital bone. Subcontinous injections of copper histidine used to bypass these defective intestinal absorption and improve copper metabolic function in these patients. Copper entry into the brain remains limited.

Where there is a MA the body wide symptoms my improve, the brain stuff doesn't improve all that much because it's hard to get it into the brain.

Let's look at copper toxicity. It's rare in the population but acutely it happens as result of copper containers where beverages are stored, especially acidic kind of beverages because they can lead to those minerals out and contaminated water supply. We use to do a lot of copper pipes and some places still use copper pipes and that can contaminate the water supplies.

You want to make sure ... It's a simple question and a lot of people, you'd be surprised, still don't do it. Are you drinking tap water or filtered water? Because a lot of times people are still drinking out of the tap and it can be a problem. Some of the acute toxicity symptoms would be abdominal pain, nausea, vomiting and diarrhea. You're not going to see that very much. What you're going to see is more of the long term type of stuff. The low grade stuff.

Some of the serious signs would be liver damage, kidney failure, coma and death. Pretty severe. Long term complications you're going to affect the liver, because too much copper gets into the liver and it just clots it up and damages it. There is a disease called Blossom's disease and it basically caused the hardening of the liver, almost like alcoholic cirrhosis.

Copper and your hormones. Women tend to have higher copper levels and more symptoms related to copper imbalance. Including yeast infections, migraine headaches, adult acne, or continuing into adulthood acne, menstrual dysfunction and even depression. When we have somebody who has got excess copper as a woman, oftentimes they're estrogen dominant.

Men can be estrogen dominant too however, it's not something that's linked just to women. Men, as they go through what we call andropause, as their testosterone levels drop and because of the genotoxin the xenoestrogens in the environment, men become estrogen dominant as well.

Women with pile of unavailable copper are often low in estrogen, but copper toxic ones are high so we see a link between estrogen and copper. Men tend to be zinc dominant, although many men do have symptoms of copper toxicity including depression, anxiety and other symptoms. Not as common in men, we see more zinc deficiencies in women as well. Let's look at the allowances.

Anyway from 1.3 milligrams in lactating women, down to 0.2 milligrams in kids 0 to 6 months. The tolerable upper limit was posted as 10 milligrams per day in adults, both men and women. We set the daily value, you know how they have those on the labels, the DV, it's 2 milligrams per 2000 calories. It's a little bit different from the daily allowance, it's a little bit higher than the daily allowance but that's what we see.

Somebody is only eating a 1000 calories, they might only be getting 1 milligram per calories. Some food sources. Some of our favorite foods are listed here. I love cashews and sunflower seeds and hazelnut, and walnuts, lentils, garbanzo beans, lima beans, soybeans, tempeh, white mushrooms, beet greens, turnip greens, spinach and kale. There's a lot of really good sources. Let's take a look at how much.

This is again taken from WH Foods, it's very small on the slides but you've got the link and I highly recommend that you go there whenever you want to check these things out. Sesame seed seem to be the highest with 1.47 milligrams in a quarter cup, 206 calories, not that much, and it's quite an amount of copper. We could see why if you're eating a good wholefoods kind of diet you're probably not going to be copper deficient.

Cashews, what is that? 0.88 milligrams. Remember, in lactating women we needed what? 1.2. In pregnant women ... In just most of us, 19 years plus, 0.9 milligram is all we need. Just a little bit of sesame seeds and cashews and mushrooms and greens, greens I usually eat much more, beet greens I don't eat much of because of the oxalate in them, but spinach are high in oxalate It's interesting, all the foods that are high in oxalates, kale. Look how easy it is to meet the daily requirements of copper and that's why copper deficiency is rare.

You might see that in people and you might see copper excess. I remember seeing one case of copper excess where a guy was eating like an unbelievable amount of macadamia nuts, which aren't listed here because they're not a common food for people to be getting but he was eating a lot of nuts and his copper levels were high. How do you test? You can look at a blood test, you can look at copper in the blood along with ceruloplasmin, so you want to look at the ceruloplasmin you can look the free copper.

The things that you's want to look at that for, Wilson's, copper storage, copper poisoning, copper deficiency. 24 hour urine test. Copper elimination, copper storage in the liver. That's the cases. If you're looking for ... Determining if somebody has Wilson's disease or excess copper, a copper poisoning, a copper deficiency you look in the blood.

If you're looking to see how well they're eliminating and how much they have stored in their liver you can do 24 hour urine and you can also do hair analysis. Maybe interesting to see how that shows up in the hair analysis. There are some drug interactions, penicillin, binds copper and enhances its elimination and it's actually used to bind copper and help people with Wilson's disease and it dramatically increases urinary increase of copper. Antioxidants can increase with a copper absorption when they're used in high amounts.

Here are some resources. There's a bunch of different studies, various national databases and some good stuff that you can read about. A lot of ... Linus Pauling Institute has a lot of good stuff on many of the minerals.

It doesn't have it on all but they have some good information and some good studies. If you want to go deeper with any of these that's what I recommend. That's the end of our copper presentation.