What Is the Cleanest Fuel for Your Body?:

A Special Interview with Jeff Volek, Ph.D.

By Dr. Joseph Mercola

DM: Dr. Joseph Mercola

JV: Jeff Volek, Ph.D.

DM: What is the cleanest fuel your body can burn? Hi, this is Dr. Mercola helping you take control of your health. Today I am joined by Dr. Jeff Volek, who is a professor in the Human Science Department at Ohio State University. He's done enormous work in the field of high-fat, low-carbohydrate diets and how it affects the athletic performance. We're in for a treat today. So, welcome and thank you for joining us today, Dr. Volek.

JV: Thank you, Dr. Mercola. I'm happy to be here.

DM: You are definitely one of the leaders in this field. You've published a lot and you've written two books that are available on Amazon. I'm wondering if you could share with us what motivated and catalyzed your interest in this field, so that we'd understand at least how you got that perspective.

JV: Sure. I kind of have to go back a few decades. My early training was in dietetics. I was classically trained that low-fat diets were healthy and that we needed to remove saturated fats and cholesterol from our diet. I was practicing as a dietician and was working with diabetics. Something didn't really click in my mind why I would be feeding diabetics a lot of carbohydrate. I continued to question myself. Maybe I didn't understand this right.

But in essence, it drove me to want to understand metabolism and nutrition at a much deeper level. I was also I guess into self-experimentation far and before this Quantified Self movement. I was at the time into very low-fat diets, thinking that was how I would optimize my own health. But I decided to experiment with a very low-carb diet. This is the early '90s.

DM: That's a prescription for disaster.

JV: That's pretty much what I thought I would experience. Just the opposite. That continued to drive my interest in wanting to understand this better. I essentially knew I had to get out of dietetics and go back to school. That took me down a huge rabbit hole, but it also coincided with my training as a scientist and really fueled my passion for wanting to understand how humans respond to diets very low in carbohydrates.

Fast-forward 20 years and 15 years of doing consistent research in this area, it's been a really remarkable decade and a half. I'll just say that the data, the results, and the outcomes from most experiments have continued to encourage me to want to study this more. They weren't negative despite the bias from funding agencies, journal editors, and so forth.

I will say I was true to the science – and still am. The science continues to point in the direction that there are a lot of applications for these diets for a large number of people. We're still sorting out a lot of the details, but clearly we need to be changing the way we feed Americans and the way we think about

nutrition in this country in order to reverse these very alarming trends that we're experiencing with obesity and diabetes.

DM: You had mentioned that you were involved with some self-experimentation. I'm wondering if you were also involved in athletics, and if you weren't what catalyzed your interest in working with athletes' performance and optimizing your diet to achieve high performance.

JV: I would consider myself an amateur athlete. I always wish I was a little better than I am. I was always interested in maximizing performance, my body composition, and really my overall health. That was certainly a part of my motivation for experimenting with diet. It was my own performance and health. I was out of high school and never good enough to compete in college. This was really more about enhancing my own health and my ability to function physically and cognitively.

Again, my experience was really positive to a low-carb diet quite to my surprise, and yet it went against everything I was taught in school, it went against most of the things I was reading in the literature, and this was very perplexing to me at the time. It's been an interesting journey to say the least. I'm realizing now I should have had more confidence in myself at a time that, "Hey I was right." The things I was reading, the things I was being taught were not really based on a lot of science and were a lot of half-truths and misinformation, which still persist today.

DM: Absolutely, unfortunately. That's what we're here to dispel to really address those. I'd like to begin that process by attempting to answer the question I opened up the conversation with: is there a cleaner fuel to burn?

Primarily, it's my understanding or impression that most of the fuel or the food that people are eating is really moving their metabolism in the wrong direction. Because really, when we eat food, most of it is converted to glucose. That's the primary fuel most people are using. There is an alternative, which we'll discuss in great detail – fat – and it burns far more efficiently. We can go into some of the specifics like respiratory quotients and some of the other aspects that you measured. But why don't we start there and differentiate between how dirty burning glucose is versus burning fat? Or is this ultimately metabolized into fatty acids and ketones?

JV: I know. I think you've put your finger on a really important point – that's fuel use and the sort of differences between carbohydrates and fat, which are arguably our two primary fuel sources although we can burn other things. But to simplify things, we can either burn carbs or fat.

If we look at the way Americans eat today, it constantly biases us towards oxidizing more carbs for fuel. At the same time, it inhibits our ability to access and utilize or oxidize fat for fuel. When you look at this from kind of a 30,000-foot level, there are a lot of reasons why it makes a whole bunch of more sense to be burning fat most of the time for fuel. That's how we evolved as humans to primarily burn fat as our fuel – not carbs – and yet that's not how we're feeding our bodies. We're running into a lot of metabolic problems, because we're constantly inhibiting our body's ability to burn fuel that we evolved to burn.

To use the term "clean," that's kind of a provocative term, but I think it is an appropriate one because there's a lot of data that there's a lot of exhaust associated with burning carbs for fuel, and by exhaust, I mean, there's a lot of free radicals, a lot of reactive oxygen species that are generated when we're burning carbs for fuel. That contributes, if not a primary driver of a lot of metabolic problems we're seeing in this country.

DM: Absolutely. I think that's the key. From my understanding, really one of the core drivers of almost all diseases is that we all have to eat and we all need fuel to live. Without generating ATP, of course, we don't survive at all. The process is how to do that most efficiently and without generating these reactive

oxygen species, which would decimate our mitochondria and contribute to almost all the diseases. It's all about keeping those mitochondria healthy.

If we could just talk a little bit more about the differences between the fat and the carbs with respect to the reactive oxygen species. I think an indirect measurement and one that you have in one of your books is that you noticed that when people are burning fat as their primary fuel, their respiratory quotient can go down as low as 0.7 as opposed to 1, which would suggest that they're generating less carbon dioxide. Because when you burn fuel, you're going to generate your carbon dioxide in water. But when you burn fat, you generate 30 percent less carbon dioxide, suggesting it's a lot cleaner fuel to burn.

JV: Yeah, that's right. And by far, the most efficient way to train your body to be able to use fat more efficiently is to remove some of the sugars and starches from your diet. That's the primary driver. That's true if you're an elite athlete and that's true if you're a type 2 diabetic. In order to get us out of this carb-based metabolism, you can exercise and you can take fat-burning supplements, but those are really, really minor compared to the dramatic effect you can get from removing carbs.

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This is partly why a low-carb diet works so well. It takes us out of this carb-based metabolism that depends on insulin levels to drive blood sugar into cells and use carbs for fuel. Because to be quite candid, that whole process is disrupted or impaired in the majority of people in this country.

I'd like to introduce another term, which is carb intolerance. The majority of us, 50 plus percent of adults in the US, are prediabetic now. That really is a form of carb intolerance. It really makes no sense if you're carb intolerant to be consuming half your energy from carbs and to be trying to force your body to burn more carbs.

Again, coming back to this idea that switching over to burning fat has tremendous benefit, not just from the fuel efficiency standpoint, which you brought out, but it overcomes an impairment (some of that's genetic) that many people in this country are faced with – carb intolerance.

DM: Before we go much further, I think it's really important to expand on what we mean by burning fat or what we refer to more specifically as fat, because there's a lot of bad fat in this country. In fact, most of it is bad and should not be consumed. It is pernicious, toxic, and will definitely make your health worse. This is any of the industrialized oils, the processed vegetable oils.

By fat, we are talking about healthy, unprocessed fat. That's available in seeds, nuts, butter, olives, fruits like avocado, or coconut oil, which are really healthy unprocessed fats that burn cleanly and can contribute… Another good one is cacao. Cacao is a phenomenal source of good saturated fats.

They can also contribute to the formation of the cellular membranes, which if you're eating these trans fats and industrialized processed oils can be highly disruptive to your physiology. It's really difficult to have any good biological function with impaired cell membranes. It has two purposes: 1) it serves as fuel but 2) it also is the foundational structural component of our biology.

JV: Sure. We can talk about preferred dietary fuels. But for the people who are obese in this country who are trying to lose weight, they're specifically trying to lose their own body fat and training their bodies to be able to access their body fat is key. When you talk about the appropriate fuels, for those people, we want them to burn their own body fat down and lose that excess adipose tissue that they're carrying around. Then once they've reached their maintenance weight, the majority of the fat that they're burning is coming from dietary sources.

As you pointed out, there are good sources, there are not-so-good sources, and then there are really bad sources. Understanding the various sources of fat, which does include endogenous sources of fat, especially for obese people, starts in this conversation of what is a well-formulated low-carb or ketogenic diet? In the heart of that discussion and an important part involves sources of fat, for sure.

DM: That's a very good point. I was jumping into the assumption of someone considering this was already at their ideal bodyweight, but that is certainly not true for the vast majority of people in this country and most of the industrialized world.

Let's talk about making that conversion to essentially allowing your body to become adapted to burn fat as a fuel efficiently. It can take anywhere from a few days to a few weeks or maybe even a few months. I'd like you to expand on it. The key, as I understand it, is to radically restrict those carbohydrates.

And what's a carbohydrate? It's important to start with the definitions. By carbohydrates, we are talking about non-fiber carbohydrates. If you have a salad, which has a 100 grams of carbohydrates in it, that's not a 100 grams of carbohydrates; it might be 90 grams of fiber and only 10 grams of really the type of carbs that will potentially cause your physiology or biology to go in the wrong direction.

Why don't we talk about the process of initiating the conversion from primarily burning carbohydrates as a primary fuel to fats?

JV: I think one point I'll make upfront is that our bodies can burn both carbs and fat, but our bodies will burn carbs first. As long as you're eating carbs, your body will try to burn those first. They're like the bully cutting in line. You may just think of them as kind of a throw-away nutrient, too, because our bodies can't store high levels of carb. We have to try to oxidize them and burn them first.

But if you're carb intolerant, again, which is highly prevalent in this country, you can't oxidize carbs, by definition, very well. We only have one alternative. That's to convert the carbs that we're eating into fat. That happens to a greater extent to folks who are insulin resistant or carb intolerant. That really sets the stage for a lot of metabolic problems.

Again coming back to how do you train the body to burn more fat, it all starts with removing the availability of carbohydrate? Because as long as it's there, it's going to take precedence and its going to simultaneously inhibit burning of fat. These are very sensitive and exquisite mechanisms in place for this to work. You eat just a single meal of carbs and your fat-burning shuts down right away.

This is why a low-carb diet works so well to shift fuel use over to fat. You restrict the amount of glucose and starches that you're consuming, and your body naturally shifts over to preferring fat for fuel. It does take, as you indicated, a certain amount of time to adapt to that, where your cells have to kind of shift over their machinery to handle the increased levels of fat and lipid-based fuels.

Because it's not used to having to deal with that, it does have to change over and make those metabolic adaptations. That takes a matter of weeks to fully manifest to get that full adaptation. But once it's there, they're fairly robust adaptations that don't just go away. This is why there is an adaptation period to a low-carb diet. It can be disrupted though if you reintroduce carbs. But a lot of the adaptations do remain.

DM: Excellent. What types of levels of carbohydrate restriction…? Again, when we're saying carbohydrates, we're referring to non-fiber carbs because if you look at the nutrition facts on a package, it will list total carbs. That's not what we're talking about. Don't get confused, because you'll get really nervous.

Because you do need carbs. You absolutely need carbs. You need most all of them from vegetables. By volume, they're not very nutrient-dense at all. You could have an 85 percent fat diet, and the volume of

the fat would be a tenth as large as the volume of the vegetables you're eating. They're nutrient dense but there's not a lot of calories in there. They're not calorie dense. That's what I meant to say; they're certainly nutrient dense. What type of numbers are we talking about? 50 grams of carbohydrate restriction a day? 75? Less than 50?

JV: It depends on how you operationally define this. If you're talking about a level of carbs that allows a person to enter into a nutritional ketosis (which is a metabolic state and is associated in increased production of ketones in the liver), then we're talking on average about 50 grams per day or less of digestible or absorbable carbohydrates.

But even that number varies from person to person. This is a really important point. We all vary how we respond to the same food. Some people can be in a full fat-burning state and full ketosis at a level of carbs that's higher than 50 grams. Maybe 70 or 80 grams. Other folks, especially those that are more insulin resistant or type 2 diabetics may require less than 40 grams or even 30 grams per day.

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This is why it's important to actually measure ketones to have an objective measure of whether or not you're truly in ketosis rather than just counting the grams of carbohydrates that you're consuming, because people do vary. That even varies within a person over time. You may be able to tolerate more carbs when you're in your 20s, but suddenly now you're in middle age and the same level of carbs is resulting in a few extra inches on your waist, your blood sugars are creeping up, you now have prediabetes, or worse.

The appropriate level of carb for an individual is bit of a moving target, but it is a very important element to personalizing a diet, which think is fundamental to this idea of personalized nutrition. It's finding the appropriate level of carb for you at any given point in your lifespan that allows you to maintain health.

DM: It sounds like 50 is a decent target to start with. If you're young, healthy, and exercising a lot, you might be able to tolerate more or maybe twice as much. If you're older and not as healthy, maybe it's half as much. The other point you mentioned is that when we talk about being able to burn fat, really the biological reflection of that is a condition called ketosis, nutritional ketosis specifically.

You can measure that. You can measure that in the blood, you can measure it in the urine (which isn't so good an idea for a number of reasons), or you can measure it in the breath – breath acetone. Those are simple things that could be done. There are specific levels that you'll look for. That's a simple way to do it.

JV: That's right. It's not saying everyone needs to be in ketosis, but we do know, through many studies now, that it's very safe and a therapeutic metabolic state to be in, especially if you're diabetic or suffering from carb intolerance. But there are people, who are naturally very insulin sensitive and carb tolerant, that absolutely don't need to be in ketosis.

This is why we need to understand that there is no one perfect diet for everyone. We need to be flexible and have a range of options for folks. But I understand that there's an enormous amount of science now supporting low-carb ketogenic diets. They are remarkably effective, safe, and sustainable long-term for folks that are suffering from carb intolerance.

DM: Some of the other diseases… One that is absolutely uncontroversial, which I think you'd have to be ignorant of the medical science behind it to deny, would be the treatment of intractable seizures. That's how a lot of this clinical work I've done was out of that, the treatment of that disorder. That's been going on for almost a century.

And then more recently, based on, initially, Dr. Warburg's work and his Nobel Prize for that in 1931, but others like Dr. Pedersen, then Dr. Seyfried, yourself, and Dominic D'Agostino its use in the treatment of cancer, which is controversial. But in my view and understanding really the foundational treatment or the basis of almost all of cancer therapies needs to incorporate this variable into the treatment program. And of course, all the other degenerative diseases probably are a big issue.

JV: Absolutely. Everything you said was spot on. This is really a super exciting time to be investigating ketogenic diets. I would argue that the obvious target here is type 2 diabetes, because that disease by definition is a carb-intolerant condition. It's absolute insanity that we are recommending type 2 diabetics to consume half their calories from a nutrient that they're intolerant to.

We justify it by just giving them more medications, which are not benign. They're having significant side effects associated with giving people more insulin and sulfonamides – including weight gain and perhaps other untoward effects –when we can absolutely reverse and put people with type 2 diabetes into complete remission with diet alone while they're on less medications or no medications.

But I absolutely agree that beyond type 2 diabetes, there are a number of applications for a well-formulated ketogenic diets. Of course, seizures we've known for 80, 90 years is remarkably effective, especially in kids who are not responsive to drugs, but that's trickling over into other areas of neurology now like Alzheimer's and Parkinson's.

I absolutely agree with you, too, that cancer makes an enormous amount of sense. I think that is the next frontier of ketogenic diets. There are multiple reasons why many cancers would benefit from a ketogenic diet, not just the decreased glucose availability influx (which many tumors depend on) but just the lower insulin response, and less inflammation, which many tumors thrive in a pro-inflammatory environment.

There are multiple potential mechanisms by which a ketogenic diet would benefit, including epigenetic effects, which we now know that the principle ketone body, beta hydroxybutyrate, is more than a metabolite. It's more than just an alternative fuel for the brain. It's in fact acting like a hormone or a potent signaling molecule that actually affects gene expression, including upregulating genes that are protective against oxidative stress and enhance the antioxidant status.

Ketosis, our knowledge and perspective on ketosis is expanding almost daily. It's all pointing toward positive health effects, which is quite interesting considering that for the last three or four decades, we've been demonizing ketones because we only associate it with ketoacidosis.

DM: Sure. One of the intriguing aspects of this, too, with respect to the signaling component are branched-chain amino acids, which would be leucine, isoleucine, and valine.

Interestingly, there's a study published last week (I'm not sure if you saw it) that looked at like 40,000 genes. They found a dozen of them that were really associated with longevity. One of these genes, its primary function was to cripple the degradation of these branched-chain amino acids. They seem to be really useful. Certainly, they're useful for building muscle mass.

I was intrigued to read in your book and to find out that these ketones share a real structural similarity to the branched-chain amino acids and seem to be preferentially metabolized. In other words, they spare those branched-chain amino acids, leaving higher levels of them around, which promote longevity and increased muscle mass. I'm wondering if you can comment on that and perhaps even the need for additional branched-chain amino acids supplementally.

JV: There's a lot of interest in leucine in particular. It's a very important amino acid and in addition to being a building block of proteins, it's an important signaling molecule for cells.

We know that a ketogenic diet – and this is going back to the classic work done by people in the ‘60s studying starvation ketosis. One of the reasons why we can survive so long without food is we enter into ketosis, and ketosis spares protein breakdown. One of a more consistent effect we see in people on a ketogenic diet is leucine levels go up in the blood, because they’re not being oxidized to the same level.

Ketones are sparing oxidation and breakdown of important structural proteins, and therefore their levels or concentrations in the blood increase and allow them to do other important signaling-type functions. I do see a very positive interaction here with nutritional ketosis and protein metabolism in general in sparing of the branched-chain amino acids in particular, which are unique in that they are a preferential fuel unlike other amino acids, which don’t really serve as a fuel substrate.

DM: Do you think there’s any benefit to adding smaller doses of branched-chain amino acids? Because the other component here… Before we go into that, before you answer that question, let me just interject a comment that I neglected to mention earlier when we talked about burning the fuels.

One of my mentors, Dr. Ron Rosedale, told me many years ago that the single most important variable for controlling the aging process is the amount of carbohydrate that you burn versus the amount of fat you burn. The more fat you burn, the slower you’re going to age essentially. I think that’s an important point to emphasize and certainly your work tends to support that. But with respect to these branched-chain amino acids, do you think there’s any…

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Anyway, the other thing is you don’t want to have too much protein either, because if you have excessive proteins, as you mentioned, you can burn that as a fuel. It’s not a primary fuel, but your body can still burn it, especially if you’re low in glucose. You don’t want too much protein. In an effort to keep the protein relatively moderate, would it make sense to supplement some of that smaller doses of protein with these preferential amino acids like the branched-chain ones?

JV: It’s a great question. We don’t really have the specific experiments and data to answer that directly, but you’re right, there is a sweet spot with protein. This is kind of an important point to make because there is a common misconception that low-carb diets are high–protein diets. I suppose they could be if you choose to do it that way.

But they naturally have to be somewhat low and moderate in protein, because protein is anti-ketogenic. Those are sweet spots. You don’t want to consume too much protein because that just doesn’t make sense plus it’s anti-ketogenic. Alternatively, you don’t want to have too low a protein and be on a negative nitrogen balance or protein balance. There is sort of an ideal protein range to be in.

Within that range, I do believe it’s important to maximize the quality of the protein. I am a general proponent of high-quality protein sources, whether that be whey protein. Most animal sources of protein maintain these essential amino acids. I do think with the potentially unique characteristics of leucine and branched-chain amino acids that we may discover that it’s beneficial to include extra leucine even within a context of a ketogenic diet.

The simple answer is I don’t know, but I suspect there are reasons. Especially if you’re an athlete wanting to enhance lean body mass, there could be some benefit to specific use of leucine in particular after exercise or even before exercise. Timing is another component or element that’s important to consider when we’re talking about anabolism.

DM: Now, leucine clearly is the most important. Most of the branched-chain amino acids forming this have all three but twice as much leucine than isoleucine and valine. Do you think it’s wise to use that as all three or just to supplement leucine individually?

JV: Yeah, I generally think including all three. Leucine is a potent stimulator of mTOR and protein synthesis in skeletal muscles. It's one thing to turn on the machinery, but you still have to have the building blocks in order to build proteins. I do think it's important that you have full complement of the essential amino acids to make sure that you have all the material there to take advantage of this signaling effect of leucine.

DM: That's the key thing. We want to build muscle mass, especially as we age, because one of the complications of aging (of course, it varies on the health of an individual) is age-related sarcopenia or loss of muscle. The muscles have most of the mitochondria. You need mitochondria to stay healthy. You really do not want to lose your muscles. That's why these branched-chain amino acids can be so important, along with resistance training. But I'm wondering what your experience is with the use of creatine in this area.

JV: That kind of takes me back to over 20 years ago. I did a lot of work with creatine. I think I probably published 15 or 20 studies. Creatine works for sure if you're wanting to enhance high-intensity exercise performance. It also helps in anabolism and augmenting increases in lean body mass, muscle mass with response to training. It's one of the few dietary supplements that has substantial amount of scientific support for it.

I don't believe it's been studied in the context of a ketogenic diet, however. But I don't see any reason why it wouldn't have those same effects in the context of nutritional ketosis. I have generally very favorable comments to say about creatine. It's very natural way to augment creative levels in muscle and therefore anabolism and high-intensity exercise performance has no side effects. I have no concerns recommending that, say, the dietary supplement to augment lean mass and high-intensity performance.

DM: It seems like a useful way to optimize the quality of your protein intake. Because if you're going to limit it, you want to make sure you maximize the value of the protein you're getting. That would be one way to do it. I'm wondering, too, sort of a bit of a tangent on some of the responses you got maybe early on and maybe even now. You've done a lot of studies with a lot of endurance athletes.

The traditional wisdom in this area is that you're going to need to carb-load. You need lots of carbs because your body is going to burn that. What has been your experience with them? What do the studies that you've done show? What type of challenges have you had combatting those who persist to the urban legend on those thoughts?

JV: To kind of set the stage a bit, the dogma in sports nutrition for the last four decades has really been that in order to perform at a higher level and recover adequately, athletes need to consume a high level of carb before, during, and after exercise. Even today, you look at current recommendations, they're quite extraordinarily high in terms of recommendations for carbs for athletes. When you talk to athletes though, there are athletes who are really struggling and not benefiting from this.

Kind of a missed or separated a parallel or paradigm shift in the sports nutrition world, we're recognizing for obesity, diabetes, and other clinical conditions that low carb has a lot of value and therapeutic applications. But we're also realizing in the sports nutrition space that these same diets could be augmenting performance in certain athletes. This is catching on.

It's certainly gained the most traction in the ultra-endurance world, where it doesn't make a lot of sense. These athletes are exercising continuously for several hours. To be quite frank, they're challenged from a fueling perspective. Because if they're eating carbs, they're in habiting their ability to burn fat optimally. They're really almost putting themselves in a situation where they're increasingly dependent on providing more carbs. We can only store a limited amount of carbs in our body as glycogen, about 2,000 kilocalories.

If you're exercising for more than a couple of hours, you're burning through the majority of that stored carbohydrate. That's when an athlete hits the wall. We know that's associated with obvious decrements in performance. How do you avoid that? You can carb-load. That's been the traditional recommendations to try to pack even more carbs into your muscles. You can do that to some extent, but it only may delay exercise fatigue by a half hour or so. That doesn't really solve the problem. It kind of almost exacerbates the problem in some ways.

The alternative is to train your body to burn more fat. If you're burning fat and sparing carbohydrates, you don't hit the wall. That's one of the most common perceived benefits of a low-carb diet for athletes. They become bump proof. They don't hit the wall. They become so good at burning fat. Even if they're not eating calories during exercise, they've got 20,000, 30,000 kilocalories on their body in the form of adipose tissue that they can access during exercise. That's more than enough to finish even a 100-mile race.

That's the benefit from a fueling perspective. It just makes so much sense that you'd be wanting to burn more fat as opposed to carbohydrate. You'll seeing this really catch on in the ultra-endurance world. These athletes are not just finishing races now, they're winning, and in some cases, setting course records on low-carb diets.

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They're not just fueling themselves during exercise on fat, they're experiencing benefits beyond that. They're recovering faster. Their metabolic health is improved. They're able to maintain a leaner body composition. It's just there's an array of benefits that extend I think ultimately beyond endurance. Now, we're seeing this used by certain athletes during more high-intensity exercise. There are certain sports where it's not just continuous low-intensity exercise.

There's a lot to sort out here in the scientific world in understanding how this is working. But clearly in the real world, it's working on a pretty extensive level now to the point that many sports teams, many athletes are switching and ditching their high-carb diets for one that's much more moderate, and in some cases, very low in carbs.

DM: Some of the other benefits that I think is important to highlight would be the resistance to having cravings that you're really never that hungry, that you have to eat, which so many of us struggle with. That's one. And then the mental clarity. It's just really… I've started this type of dietary approach, and what really impressed me was the clarity of my thinking. My thinking wasn't that bad initially before this, but it really expanded quite dramatically and remarkably that I've never seen really happened before. Those are great side effects.

JV: That's true. I think the cognitive is super exciting. If you talk to these endurance athletes that compete in 100-mile races, they need a team to be running next to them, because when they get up to 80 miles and beyond, they're often running off the trail because they're just so fuel-deprived. The brain is starving. Cognitively and psychologically, they're really experiencing rapid decline. When they switch to low-carb, they now finish these races completely lucid and thinking clearly.

It's hard not to imagine the applications here for the military. There's a tremendous interest now with ketones in the military and switching over to burning ketones and how this would affect cognitive functioning. Any strategy now that would enhance cognitive functioning would be very rapidly taken up by the military. There's going to be a lot of research I think focused in that area, especially more special operations applications. But being able to make tactical decisions in the military is very important, under very stressful conditions, sleep deprivation, environmental stressors, and so forth.

This extends beyond the sports and the athletic applications into other aspects of physical and cognitive functioning in different professions, including the military.

DM: Terrific. Can you maybe, perhaps share with us some of the exciting new research that you're working on now as an extension of what we discussed?

JV: Yeah. I'm continuing to work in the area of diabetes, because the standard of care treatment is still abysmal in managing type 2 diabetics. We have ongoing clinical trials in type 2 diabetics. We're still in the process of finalizing some of those experiments. But as I indicated earlier, you can have absolute and remarkable effect in a type 2 diabetic with diet alone, putting the disease into complete remission. But that's very exciting.

Given this epidemic of diabetes in the US and across the globe, this is something we need to figure out, otherwise, we're not only going to have just massive amounts of personal suffering, but there are huge economic implications. We spend about 300 billion dollars in the US today managing diabetes alone. That'll probably double by 2020. We're going to go bankrupt if we don't do something in the area of diabetes soon.

We're also pursuing work in cancer. It's too early to speak about the results. But one area we're focused on is breast cancer, in particular, women with advanced metastatic breast cancer. I'm very hopeful that we'll show some benefit of a ketogenic diet in combination with chemotherapy on outcomes related to tumor metabolism and other health outcomes in women with breast cancer.

On the other end of the spectrum, we're also following up with some of the work in athletes, looking specifically at how keto-adaptation affects a range of different aspects of physical performance as well as cognitive performance with a lot of military relevance incorporated into our experiments, again, under the belief that the military really needs to embrace this. There are certain applications in soldiers I think could really enhance our soldier's health and their ability to do their job if they're in a fat-burning mode as opposed to the standard rations they get now, which really don't encourage...

DM: The high-fructose corn syrup.

JV: Enhanced performance or health in any way

DM: They produce diabetes. I think the most recent projections I've seen for diabetes in the US is that by 2050, half of the country would be diabetic or prediabetic, which is insane. I have a question for you on your metastatic breast cancer trial. I'm wondering if you have incorporated 3-Bromopyruvate (3BP) in that trial as a part of your study.

JV: No, we haven't specifically. But I'd be very interested to learn more about that.

DM: Dr. Ko out of Johns Hopkins had a lot of work with that. I've never seen anything more promising, especially in conjunction with a ketogenic diet.

JV: I think there are a lot of opportunities for adjunct therapies to have synergistic effects. It may not be just one intervention that we used to approach different types of cancer but combining therapies. I think the ketogenic diet would be a great adjunct to many other therapies. Lots to do in the scientific world to kind of continue to advance that. But there's a lot of interest, especially in gliomas now. That's where the primary focus is. This brain tumor seems to be highly amendable to ketogenic diets, but I think other types of cancer too will eventually show benefit.

But right now it's a lot of basic science, animal studies, and case studies in humans, all very promising and pointing in the right direction. We're still not at a point where we have a lot of randomized clinical

trials, but there are many in the works. I suspect in the next few years we're going to start to see results pour in. I hope they're very positive. I really do think. My best educated guess is that there can be a lot of positive results to report on. Stay tuned for sure in the area of cancer.

DM: You're one of the earlier researchers who've been doing this, working with nutritional ketosis and publishing. Can you give us the impression as to the number of other researchers who are now engaged and interested and actually doing studies? Has there been a pretty dramatic increase? A slow steady? Or are more of your subordinates...

JV: Yeah, absolutely.

DM: Are they accepting your work?

JV: I'm sure they didn't invent low-carb. There are a lot of people doing low-carb ketogenic research back in the '60s and even way before that. That whole thing kind of came to a halt when we had started the whole low-fat, low-grain in the '70s and '80s, so you see very little research done with a couple of notable exceptions like my colleague Steve Phinney, who is a real pioneer publishing work in the '80s and '90s. The resurgence really started in about 2000. There really weren't too many people doing work in this area.

Myself and Eric Westman were kind of the two lone scientist and researchers out there. But it has increased exponentially over the last decade and a half. It's very encouraging now that you've got a large contingency of physicians and scientists really intrigued and motivated to not just understand this better. But I think we're at a point now where we do understand it enough to be practicing it. We've got a lot of healthcare professionals very motivated to figure out how to incorporate this and use it in their patient populations.

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I can say being kind of in the trenches for 20 years that I've never been more encouraged than the last year, even the last six months as to the level of open-mindedness and acceptance to this as a possible alternative. Now, we have a lot of work to do yet, and there still remains a lot of bias out there. But things are changing rapidly. The pendulum is definitely swinging over to the other direction for good reason. That's very refreshing and energizing.

DM: Terrific. I want to thank you for all your persistence and your leadership in this area in helping generate the research we need to provide the scientific support to implement these recommendations clinically, because that's really an important part of the process. I think it really is going to change people's lives for the better and quite dramatically really in a very simple and relatively easy-to-implement program.

You've written some books on this. Do you them there handy to show, the *Low Carbohydrate Performance* book?

JV: I'm very fortunate to run into Dr. Steven Phinney about over 10 years ago now, maybe 15 years. We've just had a tremendously synergistic relationship. I've learned so much from Steve. He's just a guru when it comes to nutritional biochemistry and understanding the *Art and Science of Low Carb Living*, which is the title of the book that we wrote together.

We really wrote this for healthcare professionals. Because no one has taught the science of low-carb nutrition or the practice of low-carb nutrition; it's not taught to physicians. It's not taught to dieticians. We felt compelled to put a lot of this information that we've acquired through our research and our clinical experience into a book.

We also wrote a book specifically for athletes because there are so many people who are active now and who are experiencing a lot of positive benefits of low carbs. This is a companion book we wrote called *The Art and Science of* Low Carbohydrate Performance, which is functionally consistent with our *Art and Science of Low Carb Living* but specifically addresses physical benefits to athletes as well.

I have to give a huge shout out to Steve who has been in the trenches much longer than I have, who has been true to the science, and who really helped advance our knowledge of low carb nutrition, and he continues to do that now. It's been a true honor to able to work with him over the last many years.

DM: Terrific. Well, thanks for all that you've done. I really appreciate your time opening our eyes to this area and all the specifics that you highlighted and pointed out to help us have a healthy framework and perspective. I appreciate the time.

JV: Thank you. I appreciate this opportunity to speak to your audience. I'm happy to come back and share any additional research findings that are relevant. Again, thank you for giving me this opportunity.

[END]