Boosting Brain Function
By: Cyndi Rodi, CrossFit Kids Magazine, March 2009

Introduction
A major topic of discussion at the CrossFit Kids Seminars is the way in which exercise improves brain function. This covers a wide scope of information including developmental markers that drive our programming for kids, methods for training that maximize learning, and improvements in cerebral physiology and cognition that are directly related to exercise and have profound effects on daily life and scholastic performance.

One question that has been raised by seminar attendees is the relationship of the research literature to the CrossFit methodology; that is, given that current studies utilize aerobic activity as their testing modality, how do we extrapolate this information into an exercise program that operates primarily in the anaerobic pathways? Can we infer that anaerobic metabolism facilitates a boost in brain function similar to that induced by aerobic metabolism? Our answers may be found by tracing the role that lactate plays within the human brain.

The Traditional View of Lactate
Lactate plays an important role in energy metabolism (See CrossFit 101, January-November 2008 for a discussion of the metabolic pathways). Recent research has sought to remove the stigma of lactate. Once believed to be a deleterious product of anaerobic metabolism, lactate has been cleared of its erroneous reputation for creating muscle fatigue and soreness. Instead, it has been shown to be an important part of the overall metabolic story.

In the anaerobic energy pathway known as “glycolysis,” intense bouts of exercise can cause the production of lactate to exceed a muscle cell’s ability to utilize it, which is commonly referred to as the “lactate threshold.” This overproduction or, more accurately, under-consumption creates a “spilling” of lactate into the blood. The lactate, now circulating in the blood, can be taken up by surrounding muscle cells for further metabolism or can be delivered to various organs within the body such as the heart and lungs. It is most notably utilized in the Cori cycle, named after Carl and Gerty Cori, who first discovered it. In this system, lactate is taken up by the liver, where it is stored as glycogen. When energy demands dictate, the liver converts stored glycogen back into glucose and sends it out to various tissues within the body to help meet energy needs.

The Brain Needs More than Glucose
Traditional wisdom tells us that the brain is a voracious consumer of glucose. It is, however, a less-known fact that the brain utilizes multiple energy sources for its functioning.

One of the most prolific of these non-glucose energy sources is lactate, which plays a key role in facilitating the energy demands of the brain. In fact, under certain conditions it is the brain’s preferred form of fuel. This means anaerobic activity, like that experienced during a CrossFit workout, produces one of the major alternative fuel sources for the brain.

There is much debate regarding how this takes place and which mechanisms provide the brain’s abilities to process lactate. One thing most researchers agree upon is that lactate can be utilized and/or distributed by astrocytes, the star-shaped caretaker or support cells in the brain. Astrocytes are in close contact with the blood and can readily take up large quantities of substances needed for energy metabolism, despite the blood-brain barrier. There are several theories under peer review at this time. The most popular of these is the astrocyte-neuron lactate shuttle hypothesis (ANLSH). Other contributing theories include the lactate-alanine shuttle, peroxisomal lactate shuttle, and the spermatogenic lactate shuttle. Discussion of each of these would require a separate series of articles. For our purposes, the existence of a mechanism or combination of mechanisms which allow for the uptake of lactate and provide for the subsequent utilization of that lactate as a fuel source within the brain is solidly established. Regardless of what theory or mechanism is found to be the correct one, it has been clearly demonstrated that lactate is an important alternative fuel source for the brain.

The Brain under Duress
Lactate is the preferential fuel source of the brain under duress. Numerous studies have shown that abnormalities in brain function and/or cessation of appropriate brain activities cause a sharp rise in the utilization of lactate within the brain. Lactate has been shown to play a protective role within the brain. This is borne out in studies of brain-damaged patients who experience sharp increases in lactate uptake levels within the first 12-24 hours following injury. The significance of this shift in fuel utilization lies in the fact that lactate metabolism requires fewer steps than those required for glucose metabolism and, so, is a more efficient way to sustain the brain during periods of stress and danger. In fact, in the direst of circumstances, glucose-sensing mechanisms within the brain are able to just as effectively sense lactate. This means that lactate can be utilized for energy metabolism in the absence of glucose. Moreover, lactate metabolism in the brain has been shown to accompany decreased oxygen consumption.

What this means to the CrossFitter is that we can count on the lactate that inevitably spills into the bloodstream during our anaerobic workouts to fuel our brains during the extreme stress of the WOD and beyond, and the oxygen...
deprivation created by high-intensity exercise is not going to negatively impact that metabolism. This makes sense when we consider that early man would have been a quick lunch for a predator if he was unable to move and think concurrently. Our brains can continue to function quite well (maybe not by the end of Fran) despite the fact that the lion’s share of glucose and oxygen is diverted to muscle cells during a workout.

**Synaptic Function**

Lactate contributes to healthy, efficient synapses. Synapses are the microscopic areas between neurons where communication takes place. Lactate is able to reactivate synapses that have been shut down by glucose depletion, whether as a result of pathology or in the case of a high-intensity workout. Lactate metabolism kicks into gear whenever the blood glucose supply has been diverted elsewhere, providing for continuity in synaptic function. Furthermore, lactate contributes to neurotransmitter homeostasis in the brain. These chemicals are the impetus and regulator of all brain activity. A state of homeostasis means that strong, efficient synapses contribute to a well-functioning and productive brain. Anaerobic activity, like that in a CrossFit workout, produces the fuel source necessary for healthy synaptic function.

**High-Intensity Exercise and Lactate Metabolism in the Brain**

Just like muscles, the brain works harder during intense exercise. The high-intensity aspect of a CrossFit workout leads to a change in energy production and consumption that is in stark contrast to the long-term aerobic activity of documented studies. As CrossFitters, we largely tax the anaerobic pathway. During bouts of intense exercise, the brain actually shifts its focus from glucose consumption and begins to use lactate as its primary energy source. Lactate, produced by anaerobic activity like that found in CrossFit, is taken up by the brain and used in processes that facilitate and enhance the continued proficiency of the brain. Herein lie the answers to our original questions.

Can we generalize the findings of the literature reporting the benefits of aerobic activity on the brain? The answer is “somewhat.” Aerobic activity has been shown to increase capillary size and produce new capillaries as a response to the oxygen deprivation induced by the exercise. How much more, then, can we assume the deprivation of an anaerobic workout would create a similar, if not accelerated, response? Ever hit near hypoxia during a WOD? The implications seem obvious. In addition, like aerobic activity, a positive effect on neurotransmitter activity within the brain brought about by anaerobic exercise and its accompanying lactate metabolism can play a major role in brain health. Beyond these, however, anaerobic activity is a completely different animal than aerobic activity and possesses its own set of mechanisms and considerations. Fortunately, we are able to demonstrate an entirely different set of benefits to the brain.

**Can anaerobic activity boost brain function?** The answer is yes. Our workouts produce a powerful brain fuel that positively impacts the brain. In fact, we can quite possibly argue that anaerobic activity is more important to the brain than aerobic activity. But that is another article.

**Sources**


