BrainVault is a revolutionary and patented neck strengthening technology designed into a customizable mouthguard that reduces the risk of concussion.

— THE PROBLEM —

SIMPLY STATED IT IS ACCELERATION!

BrainVault's patented technology focuses on the scientifically undisputed fact that the most important line of defense in mitigating concussive forces is neck strength. BrainVault - Scientifically proven to immediately increase neck strength, the most critical factor in the equation to mitigate forces that cause concussion, TBI and CTE. Unfortunately, there is currently no treatment for CTE. Prevention, therefore, is of great importance.

$$a = \frac{\Delta v}{\Delta t}$$

FIGURE I. ACCELERATION EQUATION

Acceleration is a factor of velocity divided by time. It is the rapid acceleration of the brain during an impact that causes shearing of the neural tissue in the corpus callosum that leads to TBI (see Figure 1).

Since acceleration is velocity divided by time the only way to reduce acceleration is to decrease velocity or prolong the time of impact (this is the idea behind a car bumper). But, concussions are not always caused by a hit to the head. Falling on your back, a shoulder to shoulder contact or whiplash can all cause a concussion. As long as there is enough force transmitted to the head, you can suffer a concussion.

So why doesn't a helmet work to prevent concussions? Well put it this way, if a concussion is caused by the brain rapidly accelerating inside the skull, how can a helmet worn on your head protect against this?

It can't. Helmets of any kind have not been found to demonstrate a significant change in head acceleration compared to no helmet. However, make sure you still wear a helmet as they were designed to dissipate force upon contact and protect against skull fracture.

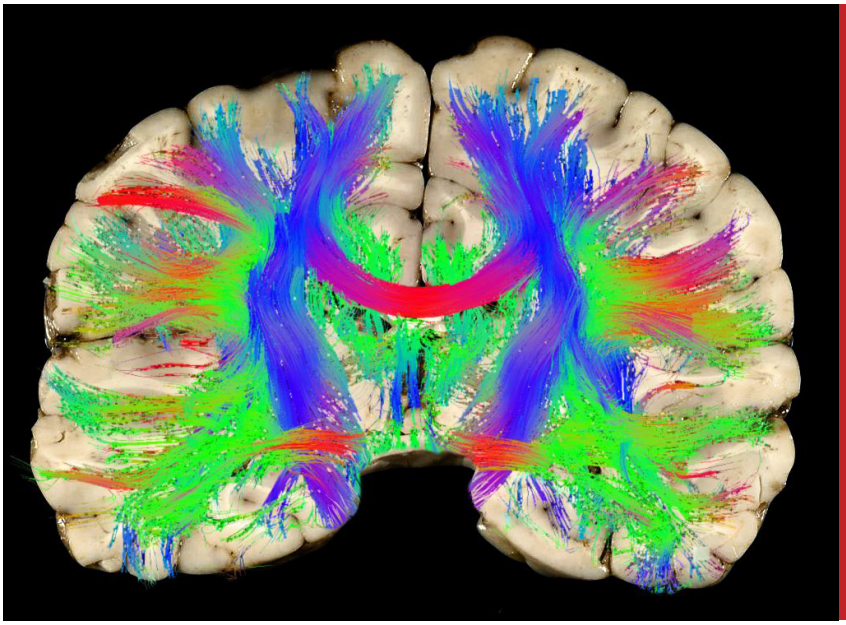
— THE SCIENCE —

THE ROTATIONAL INJURY HYPOTHESIS - RAPID ACCELERATION/DECELERATION - NEURAL STRETCH/SHEAR

In order to reduce the risk of concussion you must first understand what a concussion actually is and how it is caused. Current concussion research by Dr. David Camarillo at Stanford University's CamLab has developed a theory of concussion that has moved us away from the common "brain contusion" theory. Dr. Camarillo used 6-DOF accelerometers in custom mouthguards to capture data during collisions in American football to gain a more detailed understanding of the rotational injury hypothesis in humans (Camarillo et al., 2013).

He consequently used this data to produce a finite brain mapping model of the collision. What was uncovered was that during the collision, the forces of the blow were transmitted down the falx cerebri to the corpus callosum, which is the hard wiring that connects the right and left hemispheres of the brain. A significant amount of stretch (50%) was noted in the corpus callosum during the event and it is hypothesized that the stretch of the nerve tissue there was the root cause of the concussion (see Figure 2).

FIGURE 2



AREAS OF RED REPRESENT 50% STRETCH

Other areas of the brain that experienced a significant amount of stretch (50%) were the axons. An axon is the long cable that snakes away from the main part of each neuron in the brain and transmits electrical impulses away from the neuron, and if damaged prevent them from properly communicating (Figure 3).

It is also in the corpus callosum where degeneration occurs and tau proteins are found in cases of Chronic Traumatic Encephalopathy (CTE), as shown in Figure 4 below.

FIGURE 3

Neuron

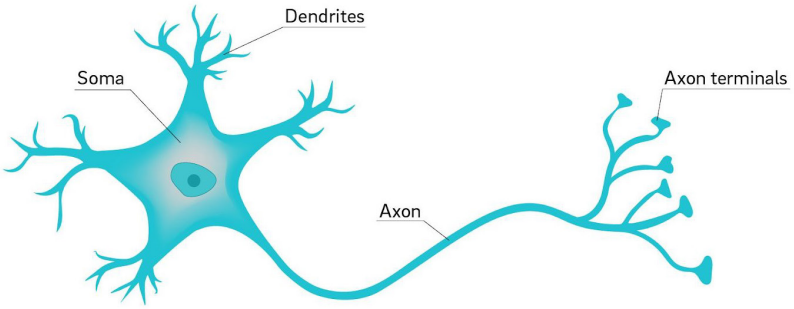
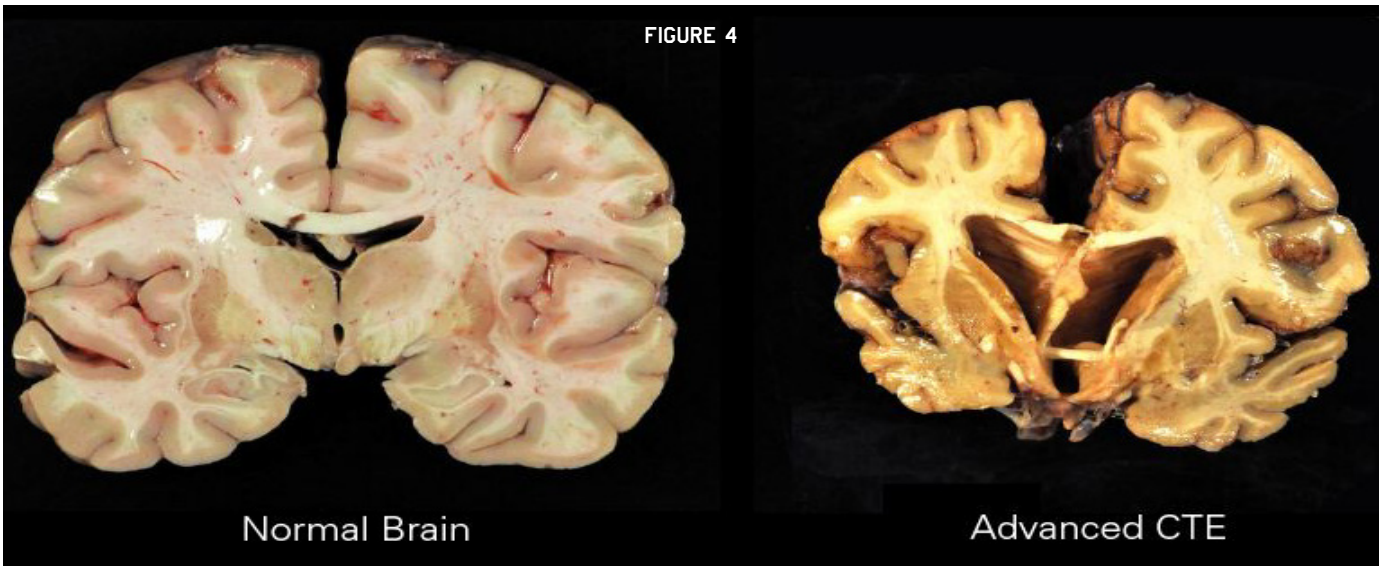


FIGURE 4



Concussion is obviously a problem in many sports with evidence suggesting that the accrual of damage to the brain may occur with repeated blows to the head even when the individual blows fail to produce clinical symptoms of a concussion.

FUNCTIONALLY-DETECTED COGNITIVE IMPAIRMENT IN HIGH SCHOOL FOOTBALL PLAYERS WITHOUT CLINICALLY DIAGNOSED CONCUSSION

Breedlove et al., used the HIT system, neuro-cognitive testing and functional magnetic resonance imaging MRI (fMRI) on high school varsity football players with a baseline set before the season. After the season, assessments were again administered. In addition to the two expected groups - those who did not report a concussion and had no neurologic changes and those who did report a concussion and had neurologic changes - a third unexpected group was identified. This group exhibited no clinical symptoms of concussion but had measurable neurologic deficits. This category suggests that there are more players suffering neurologic injury than are currently being detected.

NECK STRENGTH: A PROTECTIVE FACTOR REDUCING RISK FOR CONCUSSION

Recently, it has been identified that increased neck strength reduces concussion risk in high school sports. In 2014, a study published by Collins et al (including Dr. Robert Cantu, Co-Founder of the CTE Center at the Boston University School of Medicine) demonstrated that overall neck strength ($p < 0.001$), gender ($p < 0.001$), and sport ($p = 0.007$) were significant predictors of concussions in unadjusted models. After adjusting for gender and sport, overall neck strength remained a significant predictor of concussion ($p = 0.004$). For every one pound increase in neck strength, odds of concussion decreased by 5 % (OR = 0.95, 95 % CI 0.92-0.98) (Collins et al., 2014).

EFFECT OF NECK MUSCLE STRENGTH ON IMPULSIVE LOADS

Furthermore, Eckner et al reported that greater isometric neck strength and anticipatory activation were independently associated with decreased head ΔV and $\Delta\omega$ after impulsive loading across all planes of motion (all $P < .001$). This concluded that in male and female athletes across the age spectrum greater neck strength and anticipatory cervical muscle activation ("bracing for impact") can reduce the magnitude of the head's kinematic response (Eckner et al., 2014).

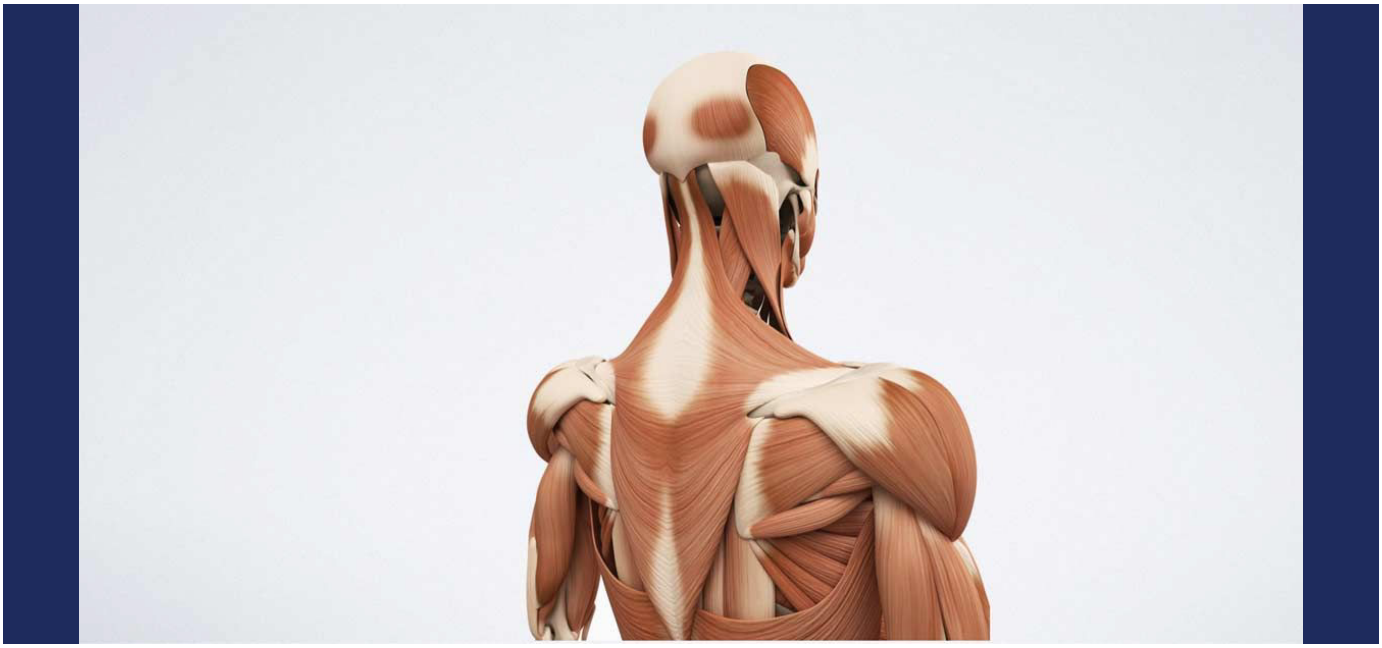
— THE SOLUTION —

BRAIN VAULT
CONCUSSION MITIGATING TECHNOLOGY

Since rapid acceleration and deceleration are the proposed mode of injury that creates the stretching and shear of the nerve tissue, it makes sense that neck strength can make a difference by decreasing the velocity during such an event. If the head could be slowed down to the point that the brain and skull move together as one, then stretch and shear could be mitigated and risk of TBI and CTE can be reduced.

There are 3 places in the body where a flexor and extensor muscle can be engaged at the same time: the neck, the spine and the pelvis. This is by design and is to protect the central nervous system by bracing for contact.

The patented BrainVault technology is intentionally designed to optimally align the lower jaw when the user bites down to clench. The IP is the jaw alignment, the delivery system is a mouthguard. Clenching the jaw in this optimal position allows for an enhanced bracing effect by the cervical musculature, a proven and effective way to slow the head down during contact to mitigate concussive forces.



HOW BRAINVAULT WORKS

It has long been postulated that more highly processed foods of the modern era have contributed to smaller facial size in humans because of less growth in response to strains generated by chewing. A study by Lieberman et al published results that support the hypothesis that food processing techniques have led to decreased facial growth in the mandibular and maxillary arches in recent human populations (Lieberman et al, 2004). Consistently, we are no longer developing a wide upper jaw to create room for the lower jaw, tongue and all our teeth to fit together properly. This is why sleep disordered breathing patterns, like snoring and sleep apnea, are at epidemic levels, currently affecting 40 million Americans.

To compensate for this growth and development issue we must twist, torque and pull our jaw back to make our back teeth touch to chew. As we do so, we begin to occlude the airway as our tongue begins to impinge on the back of the throat becoming the root cause of the problem.

The Cerebellum is the balance center of the brain that dictates head position. Our back teeth are directly connected to the cerebellum via the trigeminocerebellar tract of our central nervous system. This tract transmits proprioceptive (Proprioception is a perception or sense of the movement and the position of one's body at a subconscious level. It enables the individual to sense the relative position of body parts to the other parts of the body) information from the face to the cerebellum. An occluded airway will place the head in a compromised position, and as the jaw moves up and back, the head moves forward pulling the shoulders with it to open our airway.

It is a fact that you cannot move your head without also moving the vertebrae in your neck. Our deep cervical skeletal muscles in the neck originate and insert on these cervical and thoracic vertebrae and the base of the skull. Misalignment here moves these muscles out of their optimal alignment decreasing their ability to exert maximal force and increases fatigue rates making them tired quicker.

More superficial muscles originating on the skull and cervical spine inserted on our upper thoracic bones are also moved out of their optimal alignment compromising their ability to exert maximal force to act as a bracing mechanism for the head during impact.

Misaligned muscles cannot exert the same force and endurance due to the microscopic misalignment of the sarcomeres at the actin-myosin level (See Figure 5).

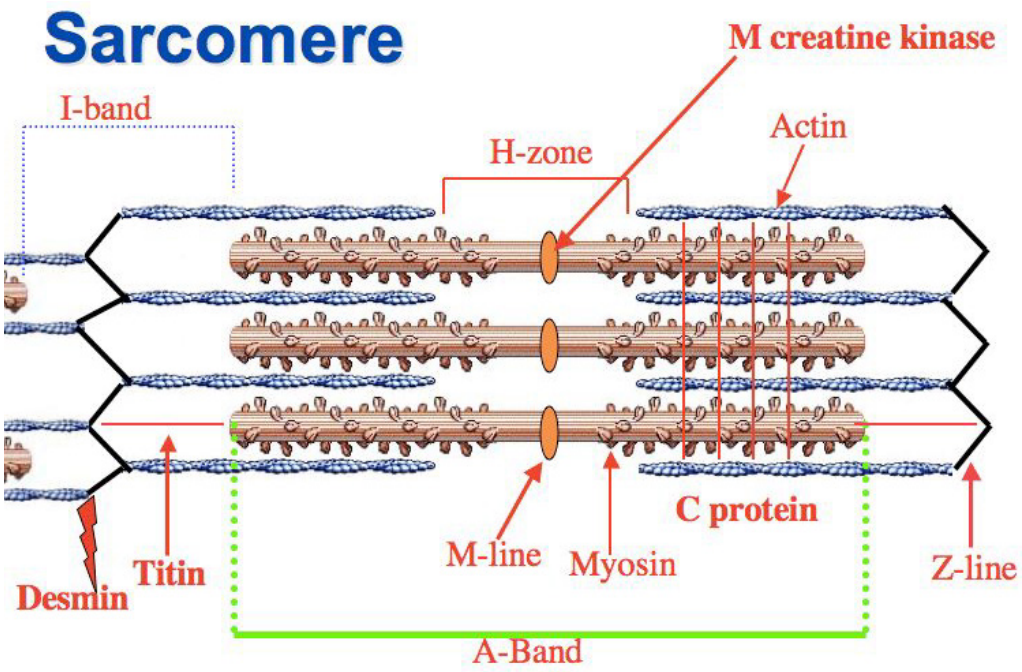


FIGURE 5

BrainVault corrects this misalignment by correcting the root cause of the problem and moving the lower jaw into its optimal position of physiologic rest, opening the airway and placing the head now on top of the cervical spine. This causes a descending cascade of realignment and results in improved force production and endurance.

If the lower jaw, upper jaw and head position are not at their optimal position of alignment, then the muscles that are attached to the supporting skeletal structures are not at their optimal position of rest length. Muscles that are at decreased or increased length of rest are incapable of exerting maximal force (imagine a head that is rotated and side bent to the right, the muscles of the neck on the left side are overly stretched and lengthened and muscles on the right side are compressed and shortened).

The BrainVault IP revolves around placing the jaw at its optimal physiologic position of rest that concurrently puts the muscles at their ideal position of rest (see Figure 6). Intentionally placing the muscles at their ideal length of rest allows the muscles to instantly exert more force for longer periods of time. This is the key to BrainVault's ability to strengthen muscles of the neck that support the head and maximally brace for contact.

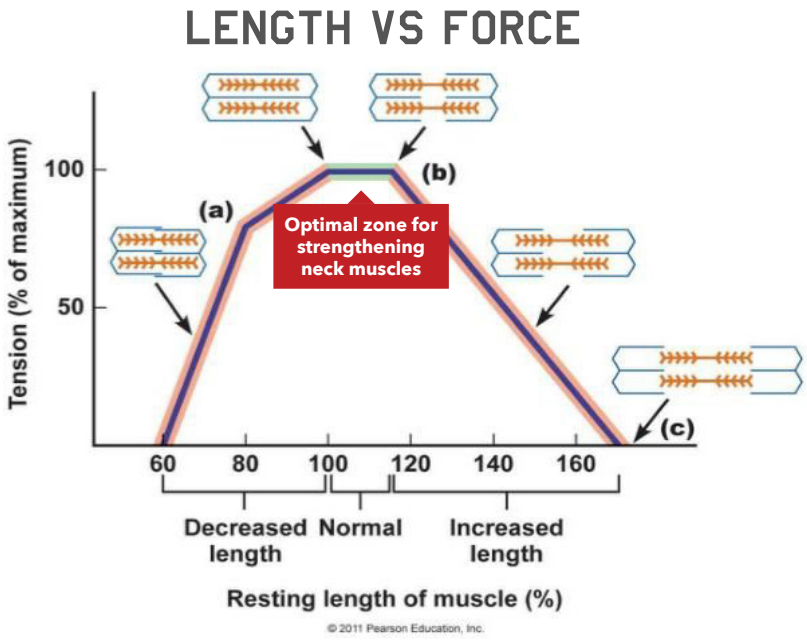


FIGURE 6

BRAINVAULT'S 3RD PARTY TEST RESULTS

In 2018, BrainVault enlisted the help of a third-party investigator, Mark Strickland, current Regional Vice President at Results Physiotherapy and Assistant Professor at The University of St. Augustine for Health Sciences as the Principal instructor of Craniomandibular Studies. Strickland was tasked to develop a protocol to accurately test for improvements in neck strength and endurance using BrainVault's patented IP.

A comparative study of neck strength and endurance was performed using a heterogeneous group ranging between 8 and 52 years in age, female and male, athlete and non-athlete.

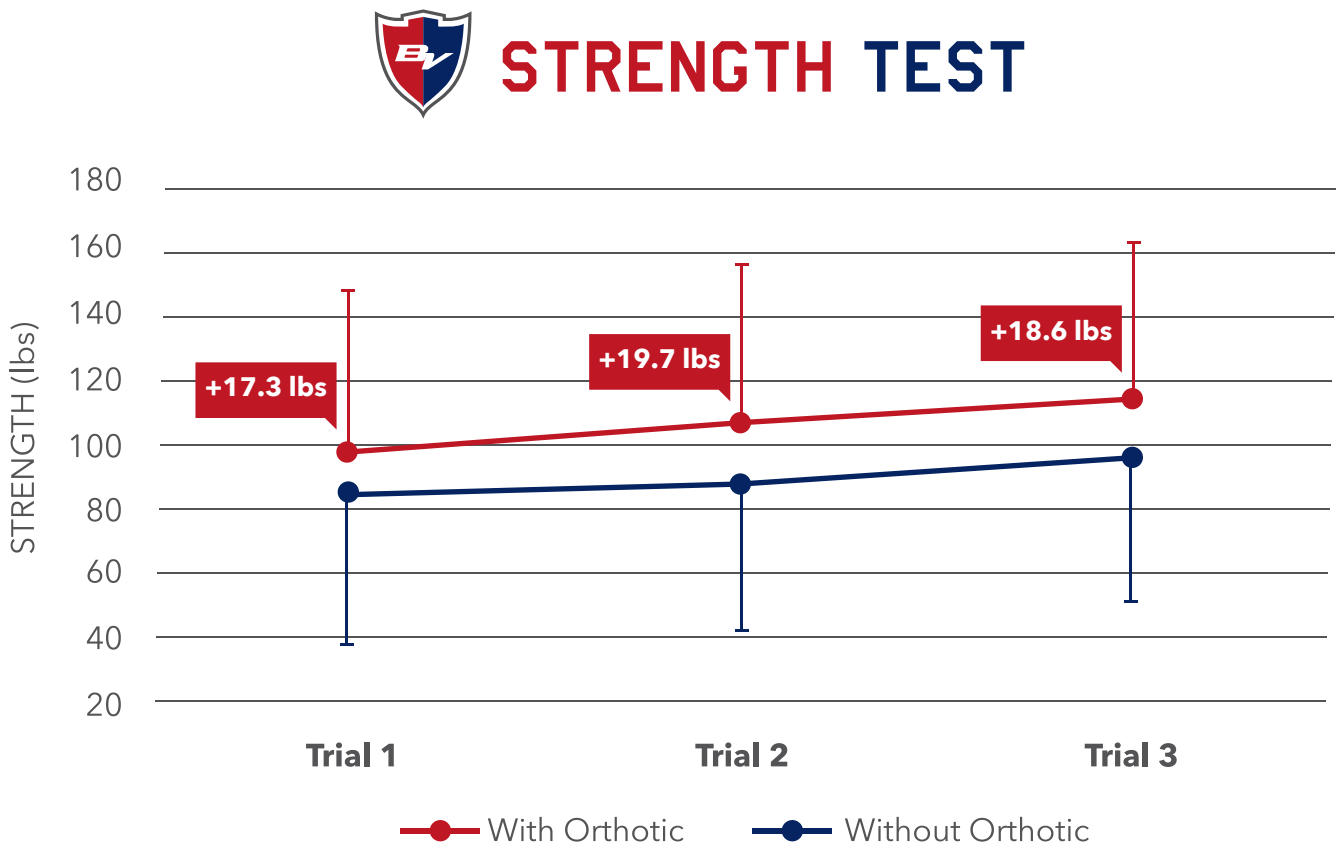
Each participant was tested with three standardized tests for neck strength and two timed tests for endurance as follows:

1. Prone extension with upper cervical bracing
2. Supine neck flexion with upper cervical bracing
3. Strength test using a blood pressure cuff to measure total change in mmHG (mm of mercury) from rest to max effort.

Subjects were tested, given 10 minutes to rest and then retested using BrainVault's IP for jaw alignment in place. The intent of our study was to demonstrate how the use of BrainVault's jaw alignment IP would increase neck muscle strength over a broad spectrum of subjects regardless of sex, ages or athletic ability.

Conclusions: The results clearly demonstrate an increase in neck strength and endurance when jaw position is corrected using BrainVault's IP for lower jaw alignment (see Figure 7 below).

FIGURE 7

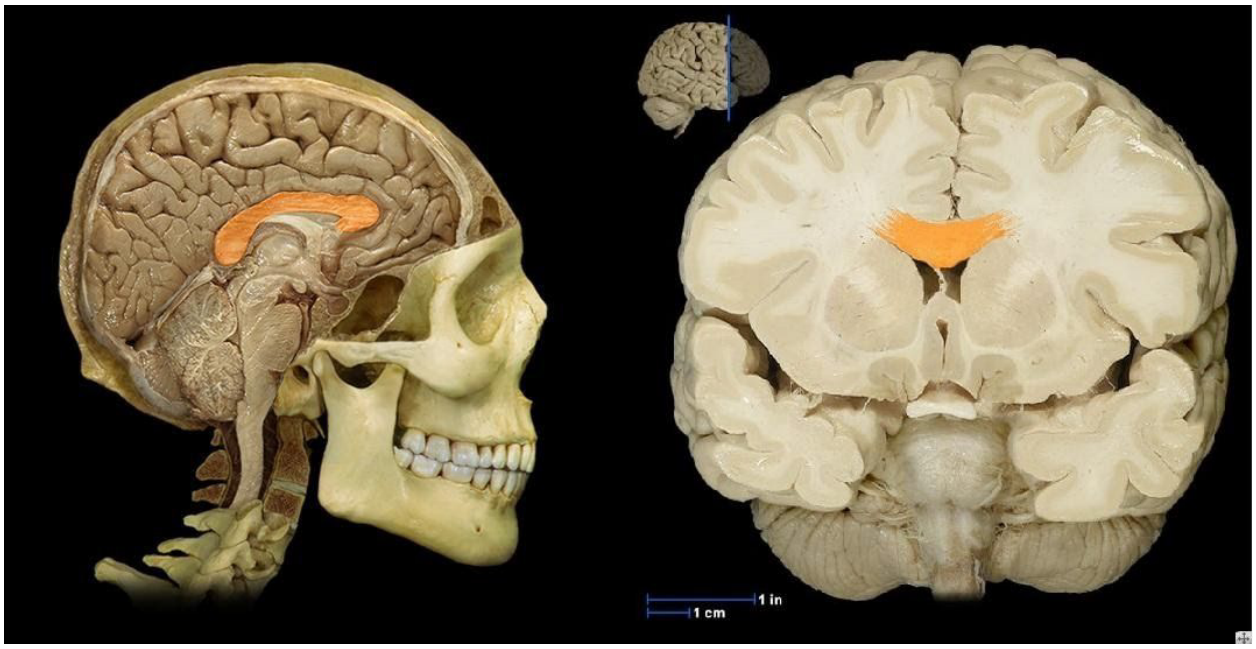


BRAINVAULT WAS SHOWN TO INCREASE NECK STRENGTH ON AVERAGE 17LBS.

— SUMMARY —

THE PROBLEM in concussion is that the head and the brain accelerate and move antagonistically to one another. This antagonistic movement causes stretching of the corpus callosum damaging the hardwiring that allows for communication between the 2 hemispheres of our brain. (Figure 8).

FIGURE 8



THE SCIENCE is irrefutable and indicates that the best way to prevent a concussion in contact sports is to strengthen the neck, slow the head down and minimize stretch and shear on the corpus callosum.

THE SOLUTION is BrainVault. Our revolutionary and patented neck strengthening technology is intentionally designed to properly align the head and neck. As a result of doing this, the neck muscles are strengthened, and the force production and endurance needed to stabilize the head during contact is maximized. The delivery device for the technology is a mouthguard, which of course, also protects the user's teeth. BrainVault is a new development and improved design to an already well-accepted piece of equipment.

Slowing the head down during contact is the key. This allows the brain and the head to move together as one, minimizing neural stretch and shear protecting the hard wiring of our brain.

We may never be able to eradicate concussions from the world of sports but we must keep striving to protect our athletes, our children, in every way possible.