

SUN HEALTH TECHNOLOGIES

THE CORRELATIONS BETWEEN VITAMIN D, CONCUSSIONS, PTSD, PHYSICAL PERFORMANCE, NFL, and the MILITARY

Researchers have found a strong association between vitamin D levels, brain function and concussions, as well as physical performance. Vitamin D plays an essential role in many aspects of maintaining optimal health including preventing disease, improving cognitive functioning and mental health. Major institutions, such as the Mayo Clinic, the New England Journal of Medicine, Harvard Medical School, Massachusetts Institute of Technology and the National Institutes of Health, have highlighted the positive benefits of vitamin D and phototherapy.

Renowned doctors and medical institutions have recommended safe sun exposure to raise vitamin D levels. Vitamin D is actually not a vitamin but a pre-steroidal hormone, which is produced predominantly through skin exposure to ultraviolet B (UVB) rays. Unlike other vitamins, which may be increased by simple oral supplementation, vitamin D is best maximized through sunlight's UVB rays. Vitamin D phototherapy mimics the sun's beneficial UVB light while minimizing the negative side effects associated with sun exposure.

Vitamin D Deficiency and Concussions Are Prevalent Among Professional Athletes and the Military

Many professional athletes have been found to have low vitamin D levels and at risk for unnecessary injury. Examples can be found in almost all professional sports. NFL football players are specifically at great risk. The American Orthopedic Society for Sports Medicine presented a study performed on eighty-nine members of the NY Giants NFL team, which found insufficient vitamin D levels in eighty percent of the team members. Those vitamin D deficient players were found to have more injuries. Additionally, the study

showed that African American players who suffered muscle injuries had significantly low levels of vitamin D. Researchers then compared the vitamin D levels of the players who had avoided injury during the previous season to those players who had sustained injuries. They discovered that the average vitamin D level of those players who had sustained injuries was roughly 20 percent lower than that of the uninjured players. The presentation concluded that treatment of vitamin D insufficiency in professional athletes might be the simplest way to help prevent injuries. [33] The NY Giant cohort is thought to be a representative example of athletes in the NFL, which evidences the prevalence of vitamin D deficiency in football players.

Another representative sample can be seen in a large study conducted on NCAA athletes, which reported that one third of the 223 participants had low vitamin D levels. [64] Cohorts with dark skin tones were fifteen times more likely to have vitamin D deficiency. Male athletes were found to be more likely to be vitamin D deficient than female athletes. The study demonstrates a high prevalence of vitamin D deficiency among NCAA athletes.

Similarly, throughout Europe there is a high incidence of vitamin D deficiency in professional athletes. In Scotland, two-thirds of its athletes have been found to have low vitamin D. [34] In Qatar, vitamin D deficiency was found to be widespread among professional soccer players. One study tested three hundred forty two players, and found that eighty four percent presented with insufficient vitamin D levels and an additional twelve percent presented with severely deficient levels. [35]

Because vitamin D deficiency is prevalent in the United States, low vitamin D levels are expected in service members as well. A recent study involving service members found that low vitamin D levels were prevalent among a representative military cohort. [30]

As well as preventing physical injury, leading experts are acknowledging that maintaining appropriate levels of vitamin D may help prevent and mitigate the risks and symptoms of brain injury. [9] Incidence of traumatic brain injury and concussion is highest among athletes and military personnel and thus it is important to look at the benefits of vitamin D on these two populations.

The Enormous Impact of Concussions, TBI, and PTSD on Athletes and in the Military

Traumatic brain injury (TBI) is a leading cause of mortality and morbidity worldwide. In the U.S. it affects over 1.7 million people annually with 52,000 cases ending in mortality, according to the CDC. In 2010 alone, the cost for treatment of TBI exceeded \$76.5 billion. One of the primary causes of TBI is concussion.

Some estimates suggest that traumatic brain injuries account for as much as one-third of veterans' injuries and affect as many as ten to twenty percent of returning veterans. [32] In response to these staggering figures, The Department of Defense and the Institute of Medicine conducted research that indicated vitamin D therapy and other nutritional interventions provided benefits in both treating and providing resilience against TBI. [10]

The NFL has a particularly high incidence of concussion. According to the NFL Players Association, there were two hundred sixty-six concussions in the 2011 season (from training camp through the Super Bowl), two hundred sixty-five concussions in the 2012 season, and two hundred twenty-eight concussions in the 2013 season. On July 7, 2014, the NFL agreed to pay seven hundred sixty-five million dollars to settle a lawsuit with forty-five hundred former players suing the league for not doing enough to prevent head injuries. Ten million dollars of the settlement is to be set aside for TBI and concussion research.

According to the NCAA, concussions are prevalent among their athletes as well, affecting at least 30,000 athletes between the years of 2004 until 2009. In fact, on July 29, 2014, a conditional settlement was awarded to NCAA athletes for several hundred million dollars to assist former players with treatment for the effects from their brain injuries. Thus far the settlement covers diagnostic medical expenses as well as establishes a five million dollar fund for concussion research. [63]

Impaired Combat Effectiveness

A recent study involving service members theorized that vitamin D deficiency initiates a loss of combat effectiveness by impairing physical and cognitive functioning of combat operators. [30] Because vitamin D deficiency is prevalent in the United States, low vitamin D levels are expected in service members as well. Thus, widespread vitamin D deficiency could increase the incidence of TBI. This study found that low vitamin D levels at the time of brain injury may both prolong and intensify concussive symptoms, which in turn prolongs recovery from mild traumatic brain injury (mTBI). Additionally, this study theorized that vitamin D deficiency also increases the risk of post traumatic stress syndrome (PTSD) by contributing to endocrine dysfunction commonly found with PTSD. Therefore, due to the fact that vitamin D status may inhibit an operator's health and performance, the study recommends optimizing vitamin D levels in soldiers before, during and after service.

Vitamin D Deficiency and Increased Risk of Suicide

As of 2010, suicide has become the most common cause of death around the world according to the Institute for Health Metrics and Evaluation. Unfortunately, this staggering figure includes the rising rate of suicide among service members. A case study of active military service members found that suicide was twice as likely when vitamin D levels were low. [31] Epidemiological studies have shown that suicide rates are highest in the spring when vitamin D

status is lowest, due to lack of UVB exposure. Similarly, this study found an increased risk of suicide in service members with low vitamin D levels. Therefore, the study concluded that vitamin D deficiency and decreased UVB exposure could be contributing factors for suicide.

PTSD, TBI, and Suicide

A study involving service members found a correlation between vitamin D status, TBI, PTSD and suicide. [29] The study found that experiencing mild traumatic brain injury (mTBI) may lead to chronic post-concussive symptoms, increasing the risk for post-traumatic stress disorder (PTSD) and suicide. Vitamin D deficiency is associated with cognitive decline, depression, and potentially PTSD through its relationship to testosterone production. Furthermore, vitamin D deficiency elevates systematic inflammation, meaning that poor vitamin D status at the time of blast may prolong inflammatory response to mTBI and exacerbate post-concussive symptoms. Additionally, vitamin D deficiency was found to decrease resilience and increase recovery times from mild traumatic brain injury and PTSD.

The Powerful Benefits of Vitamin D Phototherapy For Treatment of Concussion, TBI and PTSD

Over the last twenty years, there have been little to no advances in the treatment of TBI and concussion. Up until now, physicians have had very few options to treat traumatic brain injury. However, there is new promising evidence as to the efficacy of vitamin D and UVB therapy.

A recent study details the powerful effects of treating concussion and traumatic brain injury with vitamin D therapy. This study highlights the successful treatment of three severely debilitated TBI patients. [11] The patients began treatment while in coma, and were not expected to recover. Post treatment, these patients have returned to their mental functioning prior to their injury and are experiencing minimal long-term side affects. In this remarkable study,

treatment was comprised of only vitamin D, progesterone and omega-3 fatty acid.

Similarly, a line of case studies evidences the promising results of vitamin D therapy. In three analogous studies, rats given bilateral brain contusions were treated with a combination of vitamin D and progesterone. [12], [13], [14] Treatment successfully mitigated known long-term affects of concussion such as brain tissue loss. Additional improvements were also seen in spatial and reference memory. Specifically, vitamin D alone was shown to positively modulate neuronal apoptosis, tropic factors, inflammation, oxidative stress, and myelin and axon repair.

A recent randomized control trial with sixty brain-injured participants confirmed that vitamin D therapy improved recovery rates of TBI. [36] When compared against a placebo, vitamin D therapy in combination with progesterone increased recovery rate by twenty percent, and decreased mortality by thirty percent. Researchers concluded that vitamin D therapy has a neuro-protective effect by helping prevent cerebral edema, excessive inflammatory response, and necrosis. It also helps stimulate myelin formation, reduces free radicals, and helps prevent neuronal loss.

Vitamin D Phototherapy's Role in Concussion Prevention

Optimizing vitamin D levels through UVB may prevent concussions. Vitamin D has been shown to strengthen bones and create more resiliencies to stress and head trauma. Vitamin D has also been shown to improve muscle strength and coordination, which results in less frequent falls and resulting head trauma. Additionally, receptors for vitamin D are located on every cell and tissue of the human body, including brain tissue. Vitamin D plays a very important role in the brain of reducing edema, regulating immune response and increasing brain cell life span. [16] Vitamin D also plays a crucial role in the production of heat shock proteins. [17] These proteins make brain cells more resistant to stress.

[18] Thus, lack of sufficient vitamin D may contribute to the brain being more susceptible to concussion and TBI. [19] Therefore, correction of vitamin D deficiency should have a preventative affect on TBI and concussion incidence.

One such case study evidencing positive results in preventing concussions can be seen in a high school football team treated with vitamin D. [15] A trauma surgeon who was successfully treating his traumatic brain injury patients with vitamin D therapy theorized that this therapy would be beneficial for concussion prevention as well. Prior to commencing vitamin D therapy, almost one hundred percent of the players presented with vitamin D deficiency and the team as a whole had a season fraught with injuries and five known incidences of concussion. After vitamin D treatment, the team presented with zero concussions and almost one hundred percent reduction in injuries

Vitamin D Phototherapy's Physical Performance Enhancement for the NFL, and Professional Athletes, and the Military

In addition to preventing injury, vitamin D has also been linked to improved physical performance. [1] These physical benefits can be attributed to recent discoveries that vitamin D plays an integral role in muscular tissues, the immune system, and energy homeostasis. [3], [4], [5]. Studies have found a direct correlation between vitamin D levels, grip and quadriceps strength, physical fitness, and a decline of falls and bone fractures [5], [6]. Increasing vitamin D has been shown to improve muscle tone and strength, enhance balance, shorten reaction time and boost physical endurance. [7] Lack of the vitamin might also increase the chance of muscle injuries in athletes and the military.

Exclusively treating with UVB has also been shown to improve physical performance. For instance, a number of studies have cited the pivotal role that vitamin D played in the domination of the Russian and East German athletes at the Olympics in the 1960s through the early 1980s. "Sunlamp therapy" is often credited with giving these athletes a competitive edge. In fact, Russian and

German researchers have been writing about the performance-enhancing benefits of vitamin D since the late 1930s. [37]

Similarly, in a recent clinical trial assessing the physical performance of sixty-seven professional soccer players, UVB, as the body converts it to a steroid, was found to have a performance enhancing affect and other performance benefits attributed to increased natural steroids in the body. Specifically, sprinting performance was enhanced and a direct correlation found with increased vitamin D in a cohort with increased UVB exposure and not supplementing with oral vitamin D. [8]

Vitamin D Phototherapy versus Oral Supplementation

Despite vitamin D's many proven benefits, vitamin D deficiency has become a world wide epidemic. According to recent statistics, over one billion people, one seventh of the population, are now suffering from vitamin D deficiency. [20] It is now one of the most common medical conditions. [21] In the U.S., it has been estimated that three out of four Americans are vitamin D deficient. [22]

UVB is a far superior mechanism for increasing vitamin D as compared to oral supplementation. Clinical studies comparing oral supplementation, sun exposure, and UVB phototherapy for the treatment of vitamin D deficiency have shown that UVB phototherapy is three times more effective than controlled sun exposure [23] and eight times more effective than supplementation. [24] In fact, new evidence suggests that UVB may provide remarkable health benefits beyond vitamin D production.

Recently, researchers found that UVB exposure suppressed the clinical symptoms of MS independently of vitamin D synthesis. [25] Further, the study pointed out additional UVB benefits including production of Nitrous Oxide, which is known to reduce blood pressure and improved cardiovascular health. UVB exposure also improves mood through the release of endorphins. The study

concluded that UVB radiation may affect many processes in the human body independent of vitamin D production and additional studies were needed to further this research.

Congruently, a study soon to be published in The International Journal of Cancer found superior advantages of UVB over supplementation. [26] This study compared the benefits of vitamin D oral supplementation versus UVB phototherapy on intestinal tumors in mice. The results showed that only the UVB treated subjects showed a reduced progression to malignancy. Therefore, the study concluded UVB exposure has an inhibitory effect on outgrowth and malignant progression of primary intestinal tumors, which were effects, not achieved with vitamin D supplementation.

Additional animal studies show UVB's superiority to oral supplementation in increasing vitamin D levels. On such study compared the treatment of bearded dragons with both oral supplementation and UVB. The lizards treated with UVB increased their vitamin D levels eighteen times the amount increased with oral supplementation. [27]

UVB is also an optimal alternative to supplementation for people who cannot process oral supplementation. This malabsorption syndrome affects a large number of the population, including people with Cystic Fibrosis and Short Bowel Syndrome. A case study showed that despite this cohort's inability to increase vitamin D after oral supplementation, UVB treatment could adequately increase vitamin D to sufficient levels. [28]

UVB's Protective Effect Against Disease

In addition to UVB's superiority in creating vitamin D, a new hypothesis is being proposed that UVB has astounding benefits beyond vitamin D that play a role in decreasing disease risk. A review of ecological studies that examine geographical variations in disease outcomes demonstrate a higher incidence of all cause mortality inversely correlated with geographical UVB doses. [42-44]

UVB's protective effect against disease has also been reported in both observational studies [45, 46] as well as randomized control trials. [47, 48]

Additionally, observational studies have associated vitamin D deficiency with increased prevalence of autoimmune and other diseases. However, randomized controlled trials to treat these disease states with vitamin D supplements have not produced promising results. This has led to a recent line of research that indicates that vitamin D levels may only provide a mechanism of measuring sun exposure. Instead, UVB induced mechanisms rather than vitamin D driven processes may explain many of the benefits often attributed to vitamin D. [49-51]

Clinical evidence has clearly demonstrated the immunoregulatory effects of UVB exposure on the development of allergic asthma in both animal [52] and human models. [53] UVB-induced systemic immunosuppression has been implicated not only to down-regulate immune processes involved in multiple sclerosis, allergic asthma, and type 1 diabetes but also to control inflammatory skin conditions such as psoriasis and atopic dermatitis, as well as reduce responses to vaccines, cancer antigens, and infectious agents [54-56, 60, 61]

In addition to the vitamin D photoreceptors in the skin, there are several photoreceptors that absorb UVB photons, which have been implicated in UVB-induced immunoregulation. These include DNA and lipids of skin cells and *trans*-urocanic acid located in the stratum corneum. There are several excellent recent reviews of the cellular, biochemical, and immunological changes in the epidermis and dermis upon exposure to UVB and the subsequently increased immune activity in the draining lymph nodes. [57, 58] In addition, UVB has a regulatory effect on T cells. UVB induced T regulatory cells are able to alter antigen presenting cells from stimulatory to regulatory, as well as alter their migration patterns by changed chemokine receptor expression. [59] Thus, UVB has been found to have a protective effect against disease beyond vitamin D expression.

UVB Decreases Disease

UVB therapy has been shown to improve disease states. Multiple sclerosis (MS) is a chronic debilitating disease, with the lowest incidence in geographic areas closest to the equator and the highest incidence in regions furthest away from the equator. This relationship is believed to be related to sunlight or UV light exposure. Recent evidence with experimental autoimmune encephalomyelitis (EAE), an animal model of MS, established that UVB rather than vitamin D may be the cause of this geographical correlation. In fact, the study showed remarkable results in the suppression of EAE by UVB. The study concluded that the disease suppression was not the effect of vitamin D production but rather that UVB therapy is largely responsible. [60]

Researchers also found that UVB exposure suppressed the clinical symptoms of MS in humans independently of vitamin D synthesis. [61] Regulatory T cells (Tregs), which are induced locally in the skin-draining lymph nodes in response to UVB exposure, connect the cutaneous immune response to CNS immunity by migration to the sites of inflammation. In this study, the inflammatory response and disease symptoms were minimized with UVB therapy. Specifically, the MS patients treated with UVB phototherapy showed an increase in induced Tregs and tolerogenic DCs accompanied by the downregulation of the T-cell effector cytokine interleukin. Therefore, the UVB therapy had a positive effect on decreasing the symptoms of MS in humans.

Another study that is soon to be published in The International Journal of Cancer found superior advantages of UVB over supplementation for the treatment of cancer. This study found that UVB phototherapy inhibited the growth of intestinal tumors in mice, and inhibited the progression to malignancy. [26]

Diabetes is another disease state that appears to be inversely correlated with UVB exposure. A meta-analysis soon to be published in the journal of Clinical Endocrinology evaluated observational studies linking higher vitamin D status with decreased incidence of diabetes. However, due to the failure of studies

utilizing oral vitamin D supplementation to decrease the incidence of diabetes, the researchers theorized that the correlation found in the observational studies may be the result of exposure to UVB, and that vitamin D levels may be merely the biomarker of that exposure. [62]

Additional UVB benefits on disease states were explored in a recent study. This study cited many benefits including production of Nitrous Oxide, which is known to reduce blood pressure and improved cardiovascular health. UVB exposure also improves mood through the release of endorphins. The study concluded that UV radiation may affect many more disease states independent of vitamin D production; therefore, additional studies were needed to further this research. [63]

Safety and Efficacy of Phototherapy

In a study examining the effects of phototherapy, there has been no significant increase in the risk of developing squamous cell carcinoma or basal cell carcinoma associated with long-term exposure to UVB over 25 years. [38] Similarly, a 10 year follow up study of patient exposed to phototherapy showed no significantly increase in the risk of skin cancer. [39]

Conversely, a recent large-scale study following nearly 30,000 women over 20 years, found that women who avoid UVB are at increased risk of skin melanomas and are twice as likely to die from any cause, including cancer. [40]

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