The Effects of Stress & Exercise on the Brain

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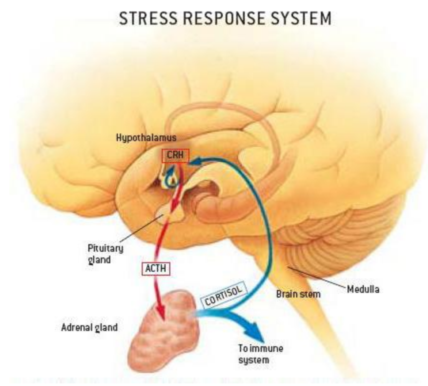
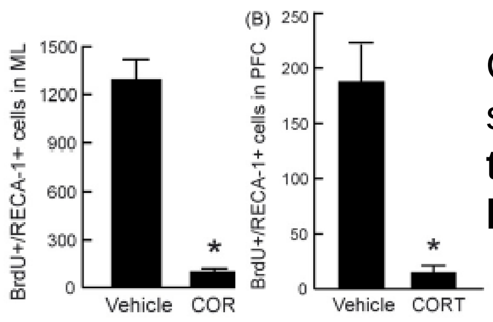
Stress & the Brain: Introduction



http://www.brainleadersandlearners.com/

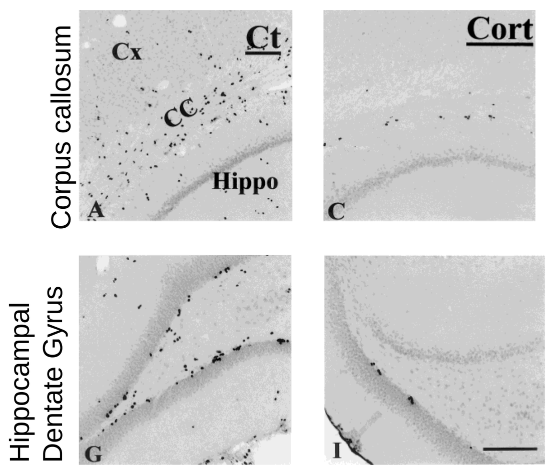
Our bodies' stress response results from a perceived threat in our environment. A stress response is coordinated by the hypothalamic-pituitary-adrenal (HPA) axis, which mediates cortisol release. **Cortisol** causes short-term physiological changes in our bodies during a fight or flight response. Therefore, cortisol in short bursts can be beneficial to our performance and survival. **Chronic stress** is a condition that results from dysregulation of the stress response system, causing inappropriate and long-term cortisol release. It is known that this chronic release of cortisol can damage many organs of our body, including the **brain**, which is the focus of this poster.

Stress & the Brain: Results



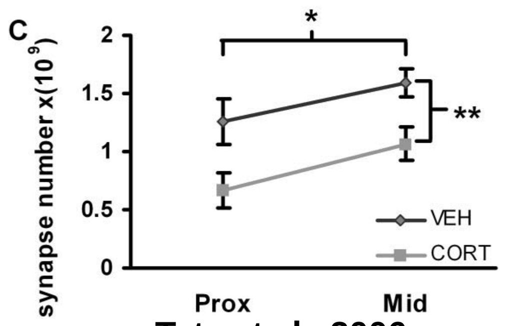
Ekstrand et al, 2008

Chronic daily subcutaneous cortisol injections in rats significantly **decreased neuronal proliferation in the prefrontal cortex (PFC) and in the molecular layer (ML) of the hippocampus.**



Alonso 2000

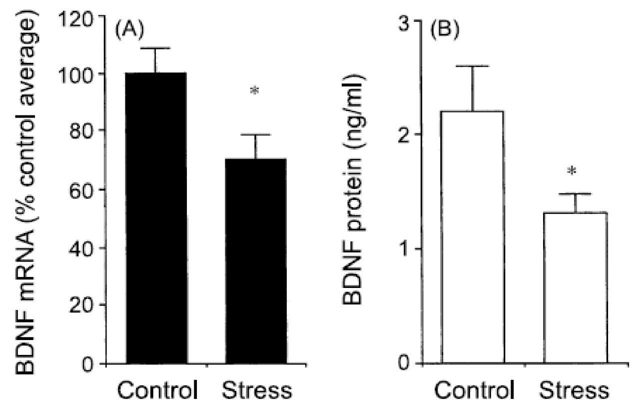
Chronic daily subcutaneous cortisol injections in rats significantly **decreased neuronal proliferation in the hippocampus and corpus callosum** (BrdU staining).



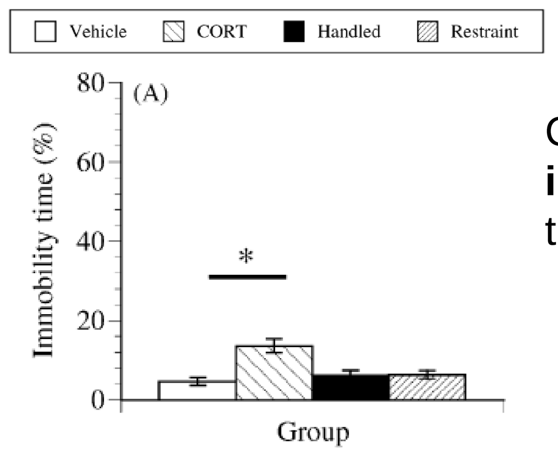
Tata et al., 2006

Sixty days of daily cortisol injections in rats significantly **decreased the number of synapses in the hippocampal CA3** (proximal = dentate gyrus).

Immobilization stress (immobilized by mesh and exposed to 1.5 cm-depth water for 1 hour) significantly **decreased expression of BDNF mRNA and protein in the hippocampus** 2 hours after stress.



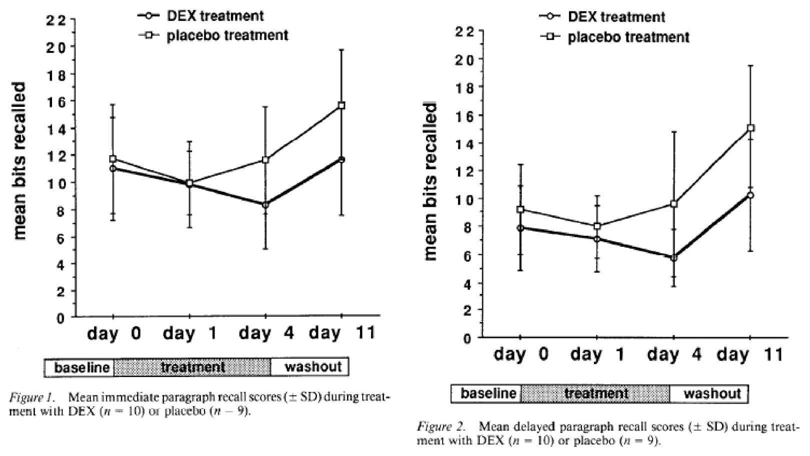
Huang et al., 2005



Gregus et al., 2005

Chronic daily cortisol injections in rats **increased depressive behavior** (immobility time) in a Forced Swim Test (FST).

Chronic dexamethasone (DEX) treatment in normal adult human subjects for four days (double blind) **decreased ability in recall during a paragraph recall task** (verbal declarative memory performance).



Newcomer et al., 1994

Stress & the Brain: Implications

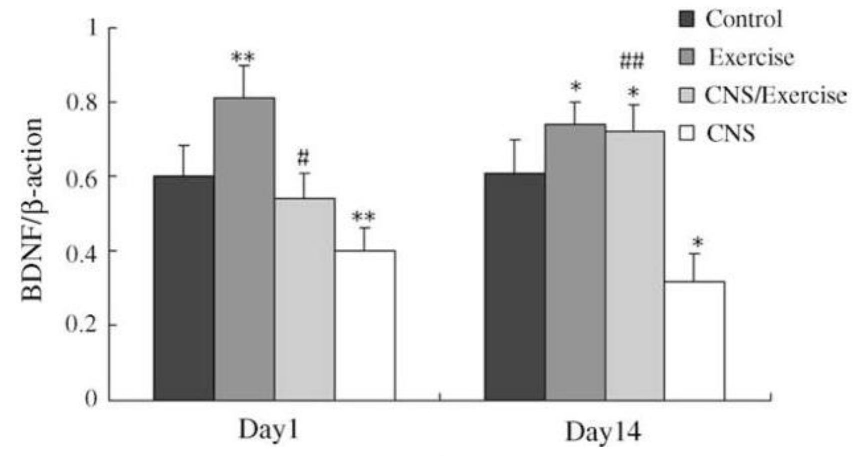
The **dentate gyrus** is a part of the hippocampus known for high levels of adult neuron proliferation. **Decreased proliferation** in this area is **linked to decreases in learning and memory**. Since stress and glucocorticoids cause decreases in proliferation (Alonso 2000, Ekstrand et al., 2008), decreases in BDNF (Huang et al., 2005), and decreases in the number of synapses (Tata et al., 2006) in this area, **stress is a likely cause of problems with memory and learning**. This is supported by the finding that treatment with dexamethasone **decreases verbal declarative memory performance** in healthy adult humans (Newcomer et al., 1994). This task is known to rely on the medial temporal lobe memory system, which includes the hippocampus.

The **hippocampus** is also known to be involved in regulation of **mood**. Therefore, it makes sense that chronic glucocorticoid treatment has also been shown to **increase depressive behaviors**. If the hippocampus is being damaged by stress, this damage should affect its regulation of mood.

Exercise & the Brain: Introduction

Exercise has been found to have robust effects in offsetting the damaging effects of chronic stress in **both young and old populations**. While exercise can benefit many organs and tissues throughout the body, perhaps the most impressive exercise-modulated changes occur in the **brain**. Exercise can modulate the HPA stress mechanism and also ameliorate the destructive neurological effects of chronic stress. A sustained exercise regimen has been shown to **enhance spatial learning and memory, facilitate neurogeneration, and offset neurological decline**.

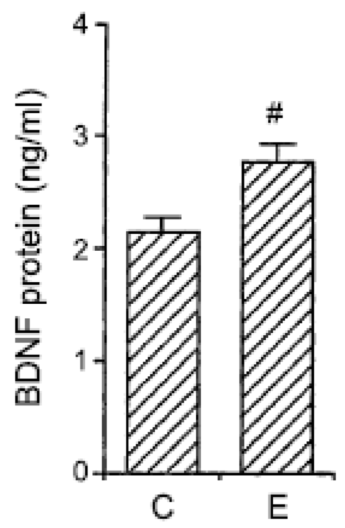
Exercise & the Brain: Experimental Results



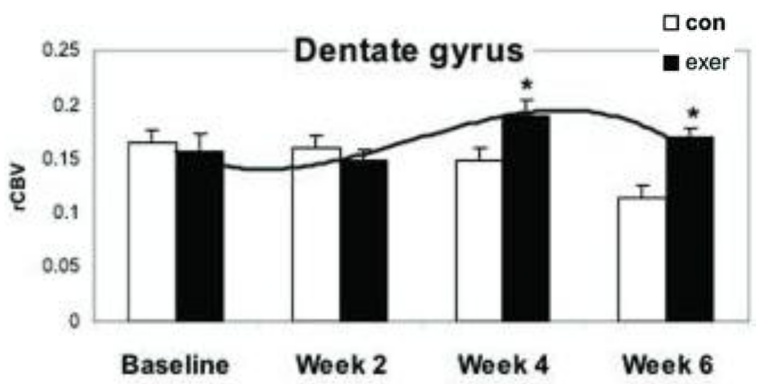
Zheng et al., 2006

The effect of exercise, stress, or both on BDNF mRNA
A two week long exercise regimen was shown to **increase BDNF mRNA levels** in chronic unpredictable stress (CNS) condition mice.

Exercise increases brain-derived neurotrophic factor (BDNF) protein expression
BDNF protein expression is significantly upregulated in rats undergoing moderate levels of exercise (E) compared to the sedentary control (C) group. It is believed that **norepinephrine release** during exercise may activate BDNF expression at the transcriptional level, thus resulting in higher protein expression.



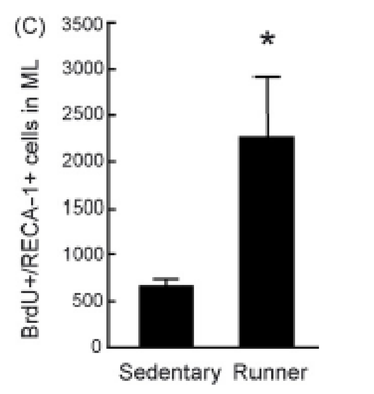
Huang et al., 2005



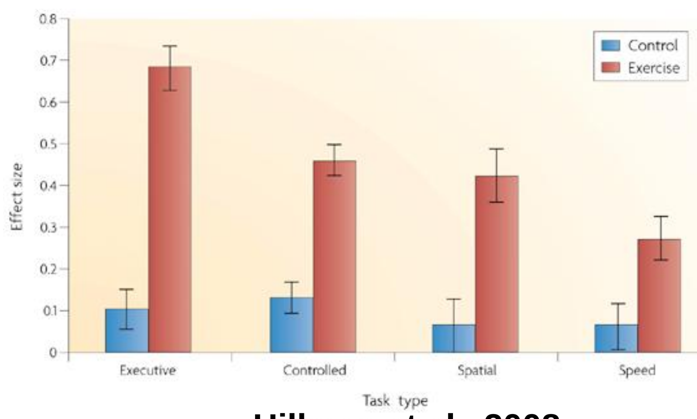
Pereira et al., 2007

Dentate gyrus blood volume increased through exercise
Exercise increases dentate gyrus cerebral blood volume (CBV) in mice. CBV is correlated with neurogenesis in the mouse hippocampus, indicating that **exercise-induced increased blood supply to certain regions of the brain may cause amplified neurogenesis**.

Regular exercise significantly increases neurogenesis
BrdU+ is a measure of cell proliferation and neurogenesis in the brain. **BrdU+ cells are significantly (about 4-fold) more prevalent in the 'runner' rats** than in sedentary.



Ekstrand et al., 2008



Hillman et al., 2008

Regular exercise enhances cognitive processes in humans
Aerobic fitness training programs significantly increased overall cognition and awareness. Among the four cognitive abilities, **executive control** or the ability to conciously guide thought, was seen to have the greatest increase due to the exercise regimen.

Exercise & the Brain: Implications

Among the most important findings is that **exercise enhances brain availability of several classes of neurotrophic factors** such as BDNF, which facilitate **neuronal maintenance, proliferation, and differentiation** in the central and peripheral nervous systems. Within a few days of beginning a regular exercise regimen, neutrotrophic factor levels are significantly increased, and remain high with sustained exercise.

Exercise has also been shown to **promote rewiring and strengthening of signaling pathways**, which in turn **enhances the brain's ability to acquire and retain information**. Exercise also **ameliorates systematic inflammation and peripheral risk factors** such as cardiovascular disease, insulin insensitivity, and hypertension, which have been found to interfere with growth factor signaling and cause cognitive decline. Finally, exercise **enhances blood flow to the brain**, thus providing oxygen and nutrients that are necessary to **protect the brain against age- and disease-related cognitive decline**.