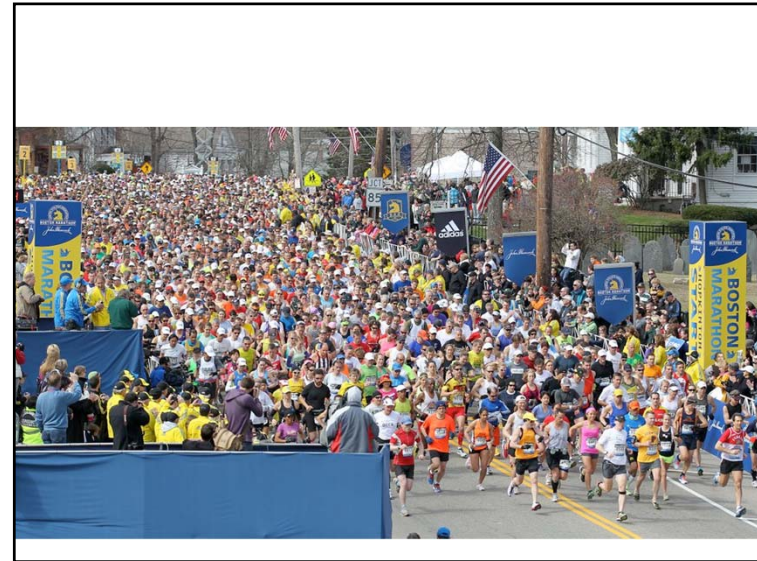



Optimizing Peak Performance in Kids:
New Research on the Brain and How to
Use Exercise and Nutrition to Achieve
Better Physical and Mental Health in
Children

John J. Ratey, MD
Harvard Medical School



BDNF



BDNF is a **THE MOTHER OF ALL BRAIN GROWTH FACTORS** which regulate the **survival, growth & differentiation** of neurons during development and is vital to continue our Brain's job of Adapting to the world- **LEARNING** .

BDNF functions to **translate activity into synaptic & nerve plasticity** in the adult animal.

BDNF is **MIRACLE GRO** for the brain and is Evolution's great gift to us that is made when we use our brain cells.

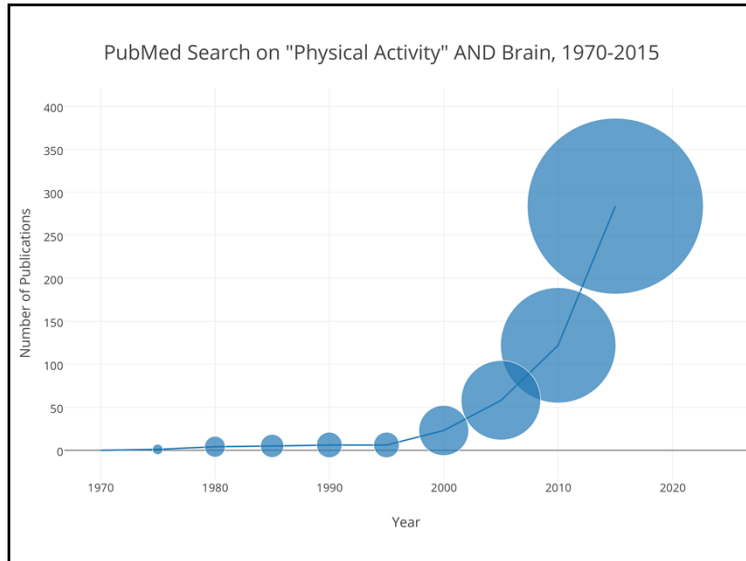
BDNF is an anti-depressant, anti-toxic stress factor and correlates with intelligence and memory.

Cotman CW, Berchtold NC. Exercise: a behavioral intervention to enhance brain health and plasticity. *TINS* 2002;25: 295-301.



RESEARCH

CONTINUES



MAYO CLINIC

- OVER 1600 SCIENTIFIC PAPERS REVIEWED
- SHOWED THAT EXERCISE IMPROVES BRAIN
- PREVENT COGNITIVE DECLINE
- LESSENS THREAT OF ALZHEIMER'S
- IMPROVES TEST SCORES AT ANY AGE
- ALSO IMPROVES MOOD, ENERGY, MOTIVATION

Brain Volume Increases With Exercise

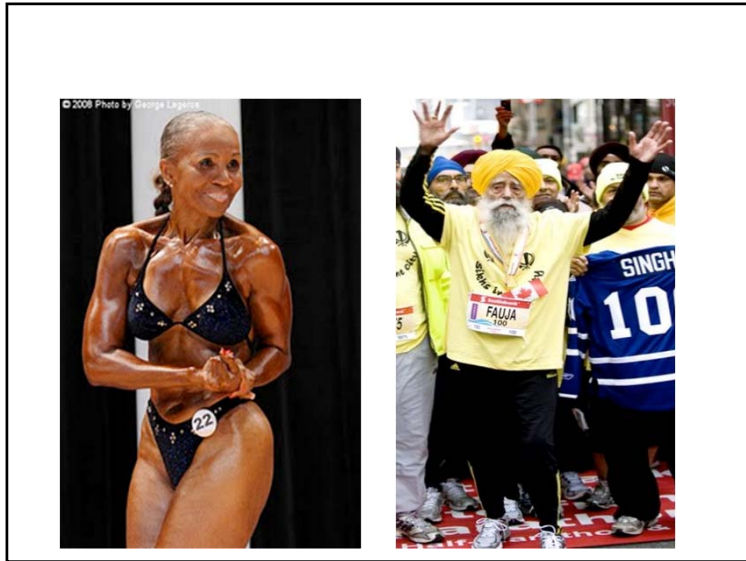
Gray Matter Increases for Aerobic Exercisers

ISTL **ACC/SMA** **AWM**
Z = 2 **A** **Z = 34** **B** **Y = 2** **C**

Colcombe SJ, Erickson KI, Scaif PE, Kim JS, Prakash R, McAuley E Marquez DX, Hu L, Kramer AF. Aerobic exercise training increases brain volume in aging humans. J Gerontol A Biol Sci Med Sci. 2006 Nov;61(11):1166-70.

Rudolph E. Tanzi

- Physical exercise
 - At least 10000 steps/day
- Healthy diet
 - Mediterranean diet: Fruits/Veggies/Nuts/Olive Oil, less red meat
 - Probiotics, Antioxidants, Limited Carbohydrates/Fats
- DHA & EPA;
- Social interaction
- Learning new things
- Get eight hours of sleep per night
 - Deep sleep clears debris from brain: *Mental floss*
- Reduce emotional stress - Meditation
- Use neuroplasticity and epigenetics to your advantage:

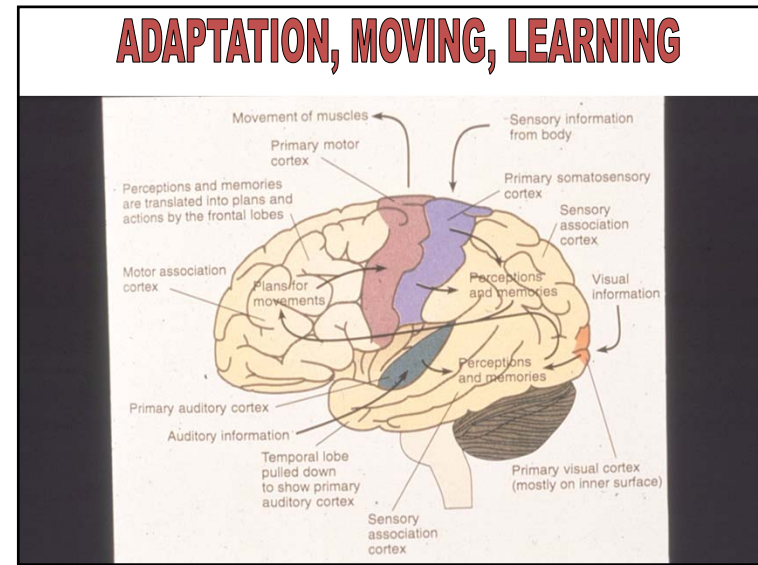


- **Definition: Neural plasticity, which is also known as neuroplasticity, brain plasticity, cortical plasticity, is the changing of the structure, function, and organization of neurons in response to new experiences.**
- Neural plasticity specifically refers to strengthening or weakening nerve connections or adding new nerve cells based on outside experiences.

THE RUNNING MAN IS THE ULTIMATE NEUROPLASTIC MAN

Hunters & Gatherers

Our ancestors were predominately of the hunter-gatherer type.
The "Running Man" was the standard of fitness that ensured survival.
Individuals who could out-run & out-plan their peers would survive.



Evolution Movement

"That which we call thinking is the evolutionary internalization of movement."

Lilinas, 2001

Every student at Madison Junior High completes a computer-based fitness test

Students spend one day a week in the school's state-of-the-art fitness center.

California Department of Education 2001 Study
 33% of freshmen in California were overweight or obese.

Naperville – District 203 – 2002 Study
 3% of freshmen were overweight or obese. 19,000 children in the district.

TIMSS – Trends in International Mathematics / Science.
 An international benchmarking test comparing the achievement of eighth-grade students . In 1999, Naperville District 203 scored #1 in science and #6 in math. An amazing 94.1% of Naperville parents were satisfied with the PE curriculum.

ANOTHER EXAMPLE OF SHAMELESS SELF- PROMOTION

www.JohnRatey.com

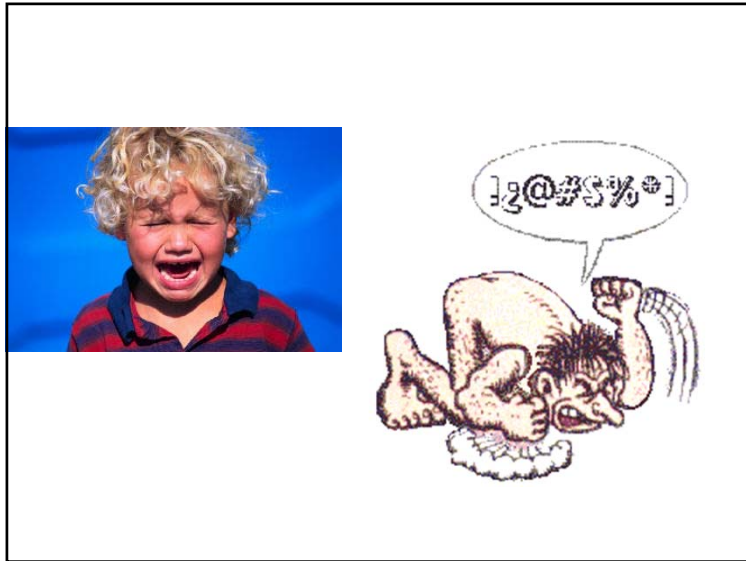
<http://sparklinglife.org>


Partially funded by REEBOK

EMOTIONAL REGULATION

EXERCISE PLAY

OPTIMIZING COGNITIVE FUNCTIONING







CHARLESTON PROGRESSIVE ACADEMY

EXERCISE IMPACTS SELF-CONTROL

Public Magnet School Grades 4-8 Approximately 120 children
 All on school breakfast and lunch programs.
 Program: Added 40 minutes of exercise in the morning
 Exercise was performed in gym in station format.

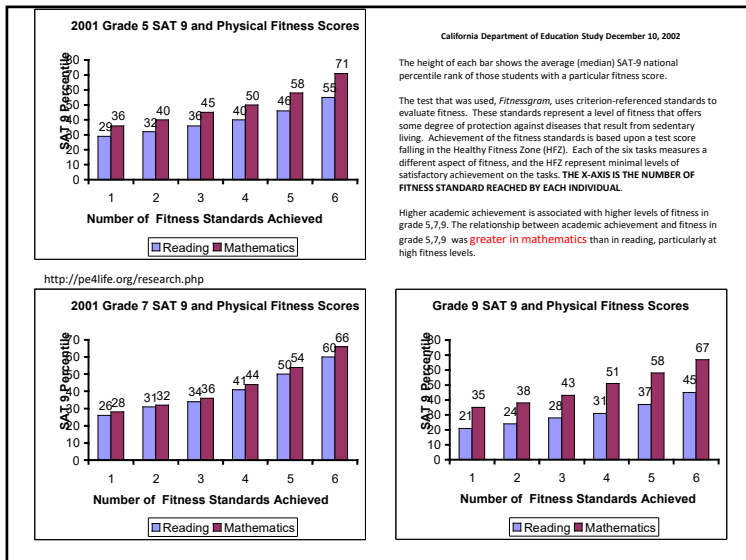
Activities included:
 Basketball Dance Dance Revolution
 Double Dutch" jump roping Pogo stick jumping

1st Semester 2006 - 2007 Outcomes: Disciplinary Referrals		
Year	2006	2007
Referrals:	661	353
Suspensions:	71	24

Teachers reported :
 Students are more focused. Students are more focused during the MAP (Measure of Academic Progress) testing as well.

Teachers observed:
 Students testing immediately after morning activities did better — meeting or exceeding individual growth targets — than middle scholars taking the test late morning or in the afternoon.



Sweden The Proof

http://www.mapzones.com Sweden Map

Love to measure and keep records

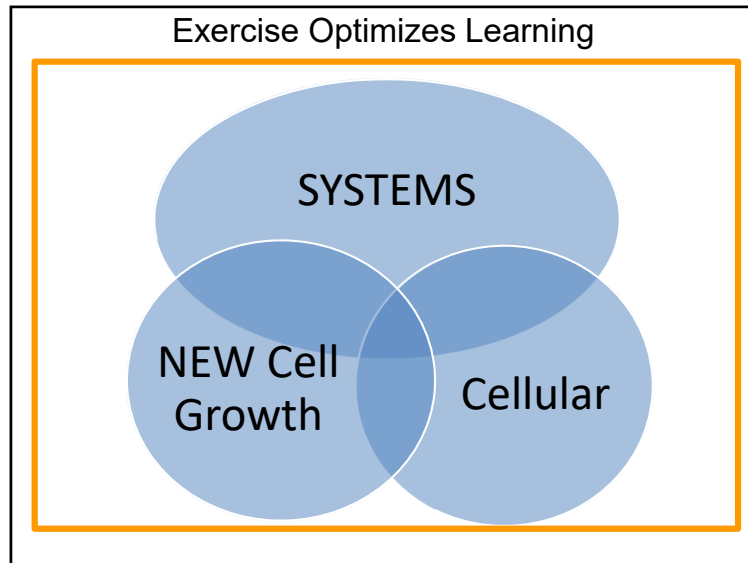
1.2 million boys born 1950-76; finished H.S. 15 and entered military 18. 270,000 brothers, 1300 identical twins

Tested cardio (ergonomic) muscle (knee, elbow, hand) and cognitive appraisal-both at 15 and 18.

Those that improved cardio fitness improved IQ and smarts. Not as much with muscle strength. Also those that improved went on to be better education, more satisfaction with life, and higher socio-economic standing.

Brothers, identical twins showed the same association-those that improved their physical fitness improved their brain power. Its not just about the genes.

"We believe the present results provide scientific support for educational policies to maintain or increase physical education in school curricula as a means to stem the growing trend toward a sedentary lifestyle, which is accompanied by an increased risk for diseases and perhaps intellectual and academic underachievement," write researchers Maria Aberg and colleagues of the University of Gothenburg in Gothenburg, Sweden in the Proceedings of the National Academy of Sciences. 2009 Nov 30. [Epub ahead of print]



EXERCISE PREPARES THE LEARNER

- Improves Impulse Control
- Improves Behavior
- Improves Attention
- Decreases Nudginess
- Improves Arousal - Lessens Fatigue
- Improves Motivation
- Helps Mood and Anxiety Regulation
- Combats Depression
- Improves Self-esteem
- Reverses "Learned Helplessness"
- Combats Toxic Effects of Stress Hormones

EXERCISE

By increasing neurotransmitter activity, improving blood flow and producing Brain Growth Factors - Miracle Grow or Brain Fertilizers - Exercise readies our nerve cells to bind more easily and stronger.

Exercise does this better than any other factor that we are aware of at the present time.

The diagram on the left shows a synapse with labels: 'Axon', 'Neurotransmitter stored in vesicles', 'Neurotransmitter released into synapse', 'Neurotransmitter attached to receptor', 'Dendrite', and 'Enzyme that destroys neurotransmitter'. The illustration on the right shows two figures building a large purple structure from blocks, symbolizing growth and learning.

Growth in the brain....especially in the hippocampus

In B

Top view
Side view

(B)

ONE HOUR after stimulus see the sprouting of new dendritic spines to connect to neighboring nerve cells—this is a structural change that is part of the cellular basis of learning.

LTP

50 μm

How the Brain Changes

Research suggests exercise spurs growth in a brain structure associated with memory, possibly leading to improved function. An overview:

BLOOD VOLUME IN THE BRAIN: NEUTRAL INCREASED

THE EVIDENCE: When new nerve cells form in the brain, their growth is accompanied by the creation of blood vessels. Researchers found that exercise increased blood volume in the dentate gyrus (a region of the hippocampus, which is used in memory), implying new cells were forming in the area.

Relative blood volume in the brain with exercise

DENTATE GYRUS

—MARC BAIN

Here we rely on the coupling between neurogenesis and angiogenesis and test whether MRI measurements of cerebral blood volume (CBV) provide an imaging correlate of neurogenesis.

Eleven healthy subjects (mean age 33, ranging from 21–45 years; two males and nine females) participated in the study, completing a 3-month aerobic exercise regimen. Cognitively, individuals performed significantly better on trial 1 learning ($F = 7.0, P = 0.027$) after exercise, with a trend toward improvement on all-trial learning ($F = 5.0, P = 0.053$) and delayed recall ($F = 5.0, P = 0.057$). There was no effect on delayed recognition ($F = 0.19, P = 0.67$) or source memory ($F = 0.15, P = 0.25$) (Fig. 4a). To test that cognitive improvement was related to exercise *per se*, we found that individual changes in trial 1 learning were correlated with individual changes in VO_{2max} ($r = 0.660, P = 0.037$).

Pereira AC, Huddleston DE, Brickman AM, Sosunov AA, Hen R, McKhann GM, Sloan R, Gage FH, Brown TR, Small SA. An in vivo correlate of exercise-induced neurogenesis in the adult dentate gyrus. *Proc Natl Acad Sci U S A*. 2007 Mar 27;104(13):5638-43.

SOURCES: NATIONAL ACADEMY OF SCIENCES OF THE U.S.A., COLUMBIA UNIVERSITY

Fitness, Hippocampus Size, and Memory

- Kids who were fit and who had better memory, also had larger hippocampi
- Fitness increases neurons, connectivity- 28 fit 21 non

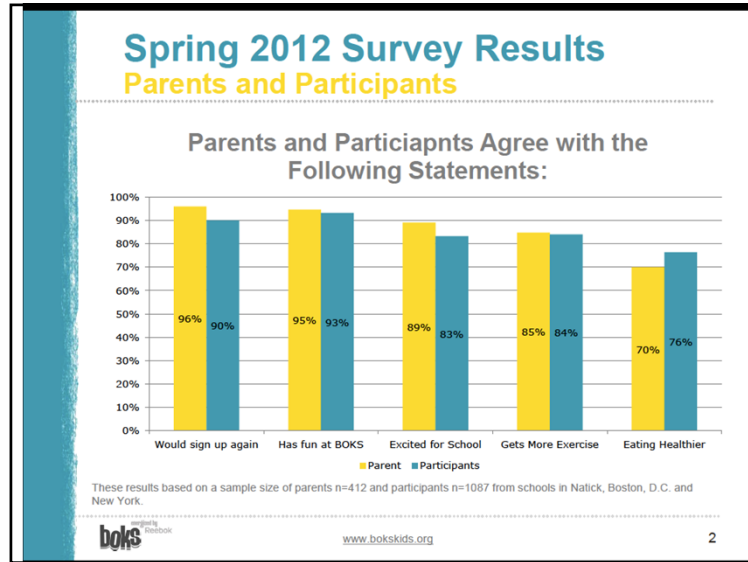
Chaddock L, Erickson KI, Prakash RS, Kim JS, Voss MW, Vanpatter M, Pontifex MB, Raine LB, Konkel A, Hillman CH, Cohen NJ, Kramer AF. [A neuroimaging investigation of the association between aerobic fitness, hippocampal volume and memory performance in preadolescent children.](#) *Brain Res*. 2010 Aug 21. [Epub ahead of print]

“If you are in education, you are in the business of brain development”

If I only had a brain!

There is no anti-brain environment worse than the classroom and cubicle

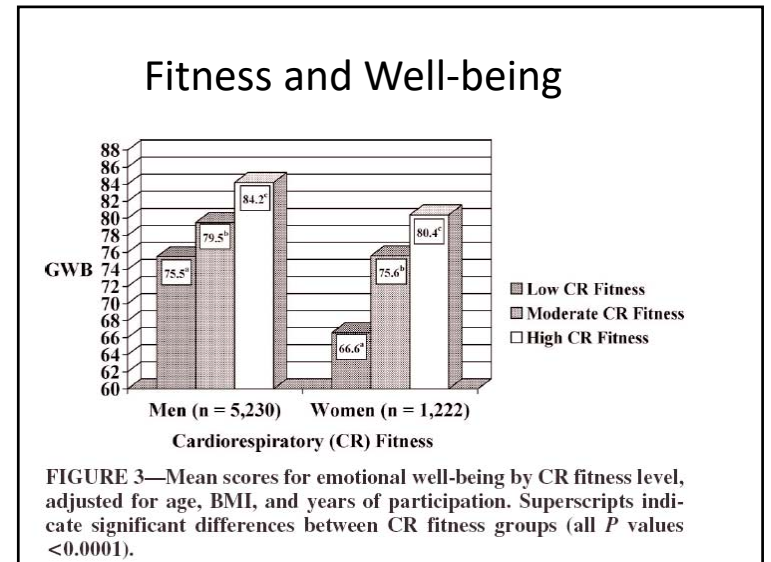
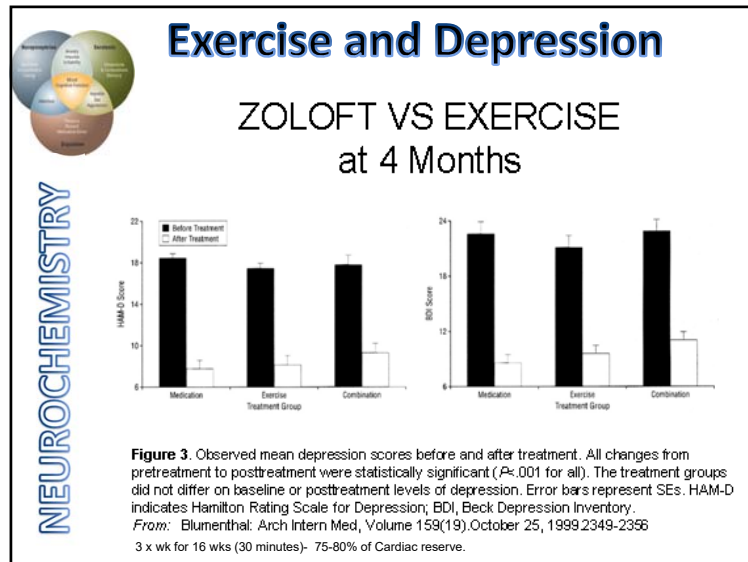
Harvard on the Move, a new initiative sponsored by President Drew Faust (from left), kicked off with a panel discussion at Sanders Theatre on Wednesday. Panelists included Daniel Lieberman, professor of human evolutionary biology and department chair of human evolutionary biology in the Faculty of Arts and Sciences, Christopher McDougall '85, author of "Born to Run: A Hidden Tribe, Superathletes, and the Greatest Race the World Has Never Seen," and John Ratey, an associate clinical professor of psychiatry at Harvard Medical School.

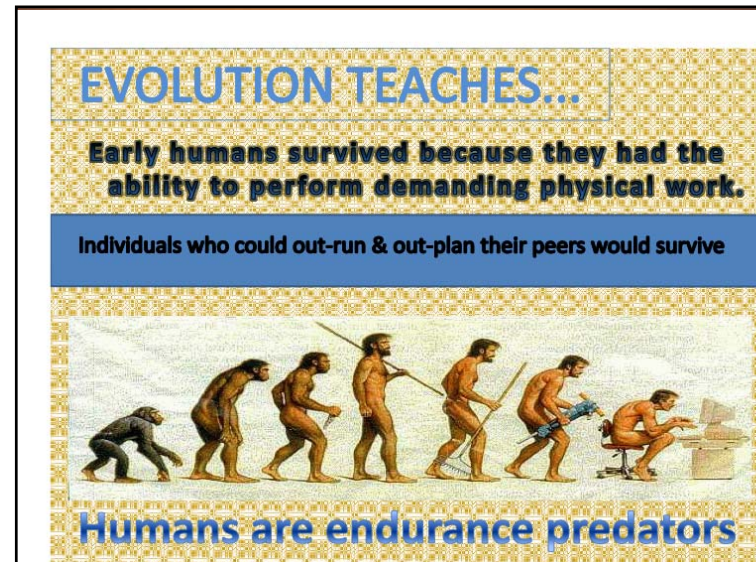
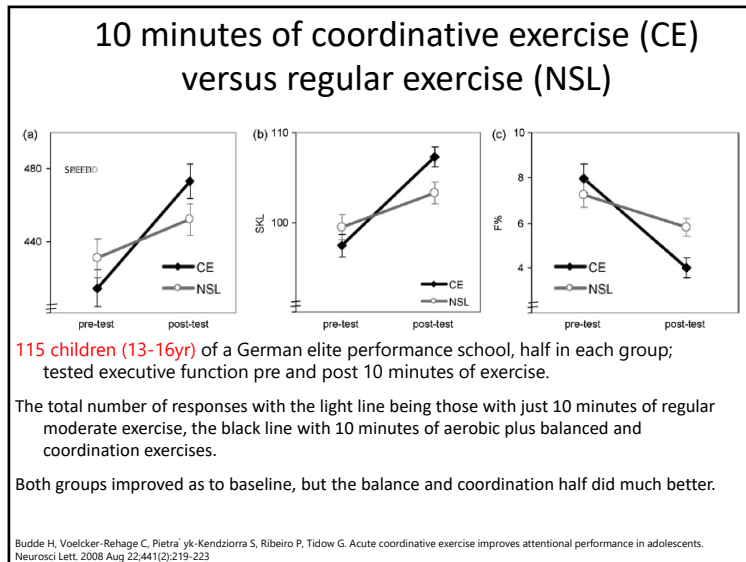
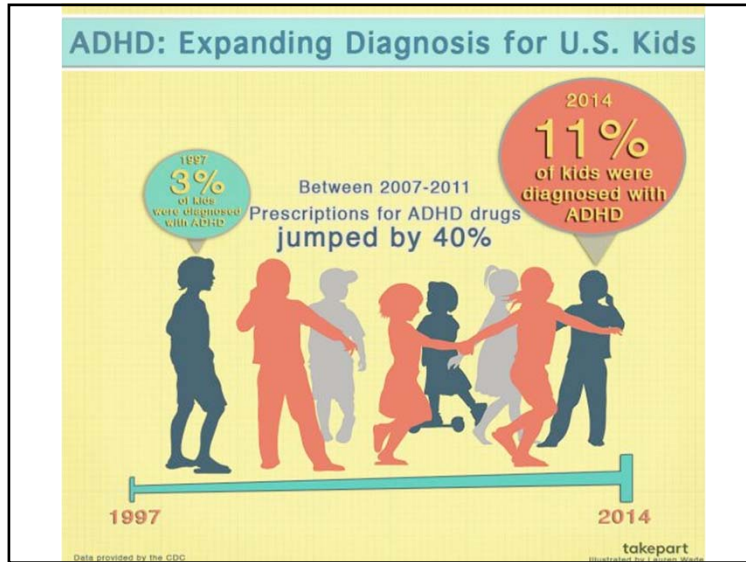


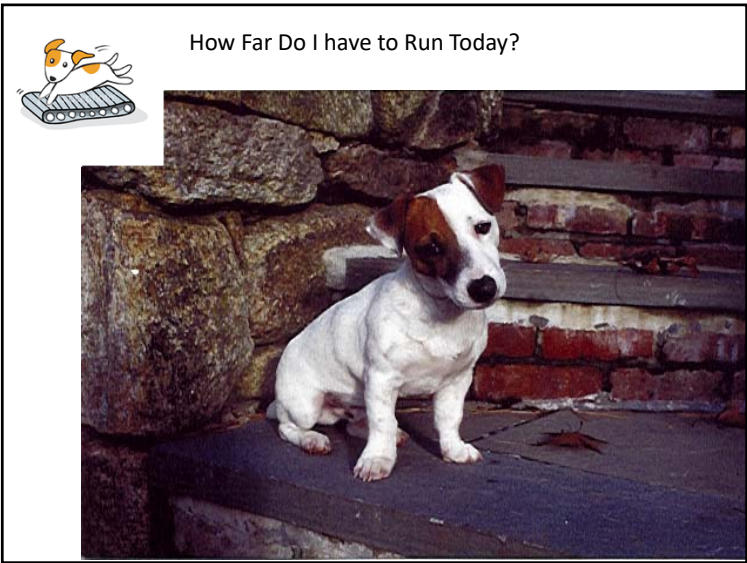
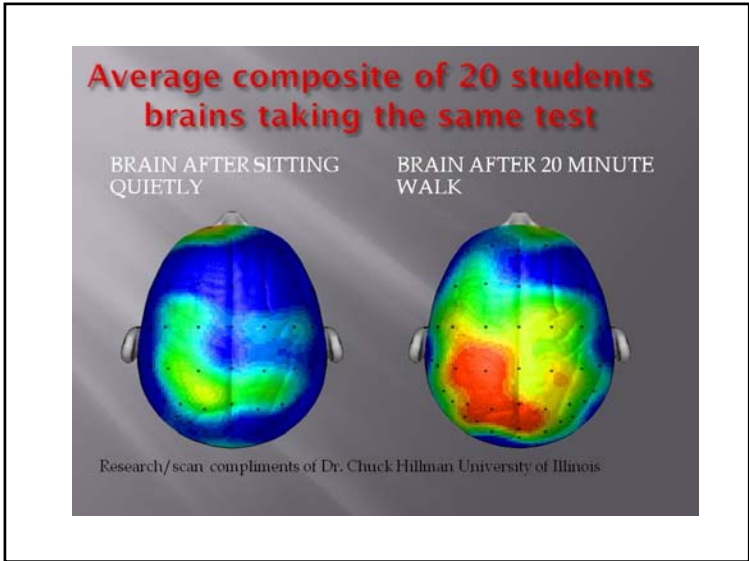
IF YOU'RE IN A BAD MOOD, GO FOR A WALK...

IF YOU'RE STILL IN A BAD MOOD, GO FOR ANOTHER WALK.

HIPPOCRATES







Exercise & Learning The JACK Effect



NO RECESS



Aerobic Fitness and Inhibition in Young Children: Moderating Roles of ADHD Status and Age. [Brassell AA¹](#), [Shoulberg EK¹](#), [Pontifex MB²](#), [Smith AL²](#), [Delli Paoli AG²](#), [Hoza B¹](#). [J Clin Child Adolesc Psychol](#). 2017 Sep-Oct;46(5):646-652.

- 91 ADHD at risk and 107 typically developing
- assessment of aerobic fitness
- and a flanker task requiring variable amounts of inhibitory control
- the positive relation between aerobic fitness and interference control was only significant for younger children with ADHD risk
- START YOUNG WITH ADHD KIDS

The present review selected a total of 16 interventional studies

- This systematic review has investigated the acute or chronic effects of PA on cognition and behaviour in children and adolescents with ADHD. The main results showed that PA improves executive functions, increases attention, contributes to greater planning capacity and processing speed and working memory, improves the behaviour of students with ADHD in the learning context, and consequently improves AP.
- . All studies have shown positive effects of PA on cognition and 35.5% on the behaviour of young with ADHD. The benefits of PA differ according to the intervention time. A PA session of 20–30 min (intensity 40–75%) will have a positive acute effect on processing speed, working memory, planning and problem solving. However, the duration of these effects on behaviour can be contradictory and vary depending on age. Systematic PA (≥30 min per day, ≥40% S. Suarez-Manzano et al. *Research in Developmental Disabilities* 77 (2018) 12–23 21 intensity, ≥three days per week, ≥five weeks) further improves attention, inhibition, emotional control, behaviour and motor control. More research is needed to justify the acute and chronic effect on the cognition and behaviour of young people with ADHD.

Acute and chronic effect of physical activity on cognition and behaviour in young people with ADHD: A systematic review of intervention studies. [Suarez-Manzano S¹](#), [Bautista A²](#), [De La Torre-Cruz M²](#), [Martinez-Lopez E³](#). *Res Dev Disabil*. 2018 Apr 3;77:12.

Exercise and ADHD 1

- The results showed a significant increase in the speed reaction and precision of response after an intervention of 20–30 min, but at moderate intensity (50–75%). However, for Flohr et al. (2004) there was no improvement in the simple mathematical problems solving of children with ADHD after a 25 min cycloergometer intervention at low (40–50%) or moderate intensity (65–75%). Finally, three other studies with interventions of 20–30 min of exercise in children (Chang et al., 2012; Labban et al., 2009) and adolescents (Piepmeier et al., 2015) obtained benefits in executive functions and planning and organization processes
- PA and sports programs applied for 12 weeks—one 60 min session per week—improved motor performance, visuospatial performance and working memory. Pan et al. (2015) applied a table tennis programme—two 70 min sessions per week—for 12 weeks. The results showed improvements in locomotor and object-control skills, and in executive function and planning. Finally, two studies observed a significant increase in brain activity. Huang et al. (2014) conducted MVPA in a waterway for eight weeks—two 60 min sessions per week—and Choi et al. (2015) conducted MVPA in a terrestrial environment for six weeks—three 90 min sessions per week—. The results of both studies showed higher activation in the right frontal lobe and right temporal lobe in children, and a decrease in theta/alpha ratios in male adolescents, respectively.
- McKune et al. (2004) revealed that an intervention of MVPA—at 50–70%—improved the behaviour of young people with ADHD from the third week of treatment. In addition, at the end of five weeks, they observed improvements in emotional and attentional control, and in motor skills. These results are similar to three more recent studies which also used MVPA. On the one hand, Smith et al. (2013), observed improvements in behaviour, reponse inhibition, Conner's score, oppositional score, and a decrease of inattention after eight weeks of 30 min a day at the beginning of each school day. Hoza et al. (2015), after 12 weeks of aerobic PA, obtained improvements in ADHD symptoms such as behaviour, decrease of inattention and bad mood. Furthermore, Verret et al. (2012), found improvement in muscle capacity and motor skills, attention functions, reponse inhibition, and information processing after 10 weeks of MVPA after three 45 min sessions per week.

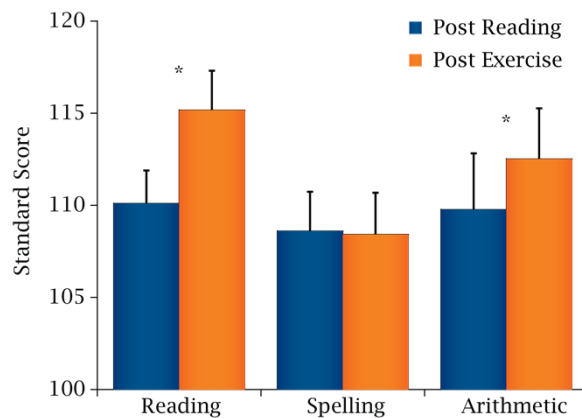
Acute and chronic effect of physical activity on cognition and behaviour in young people with ADHD: A systematic review of intervention studies Sara Suarez-Manzano, Alberto Ruiz-Ariza, Manuel De La Torre-Cruz, Emilio J. Martínez-López,* Research in Developmental Disabilities 77 (2018) 12–23

Exercise and ADHD 2

- As an complement to the above strategies, treatments based on PA have recently emerged. Recent studies have shown that the PA practice is associated with an improvement in processing speed, working memory, planning and problem solving (Chuang, Tsai, Chang, Huang, & Hung, 2015; Piepmeier et al., 2015; Pontifex, Saliba, Raine, Picchetti, & Hillman, 2013). Katz et al. (2010), observed that children with ADHD who performed high-intensity exercise in Physical Education (PE) class were able to reduce their stimulant medication intake. This was due to an increase in norepinephrine and dopamine levels in the brain, and a biological adaptive response of brain function to the stimulus generated by exercise (Wigal, Emmerson, Gehricke, & Galassetti, 2012).
- In the majority of studies, the behaviour of young people with ADHD was measured using standardized parental questionnaires (Child Behaviour Checklist) and teacher questionnaires (Conner's Teacher Rating Scale)
- The seven studies that analysed the acute effect of PA on cognition were longitudinal studies with intervention, all of them controlled by exercise intensity. Five used treadmills (Chang et al., 2012; Chuang et al., 2015; Labban et al., 2009; Pontifex et al., 2013; Tantillo et al., 2002) and two used a cycloergometer (Flohr et al., 2004; Piepmeier et al., 2015). Tantillo et al. (2002) submitted young people with ADHD (8–12 years) to a maximum stimulus and another submaximal stimulus of 5–25 min. In

Acute and chronic effect of physical activity on cognition and behaviour in young people with ADHD: A systematic review of intervention studies Sara Suarez-Manzano, Alberto Ruiz-Ariza, Manuel De La Torre-Cruz, Emilio J. Martínez-López,* Research in Developmental Disabilities 77 (2018) 12–23

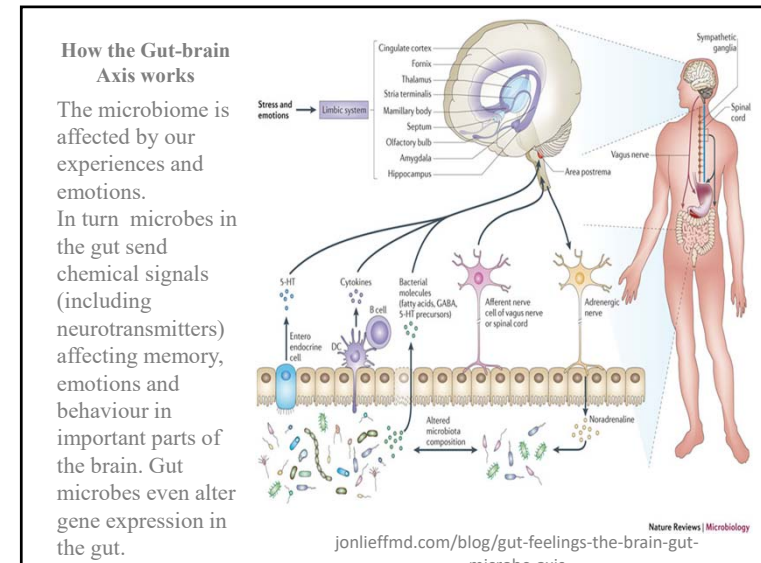
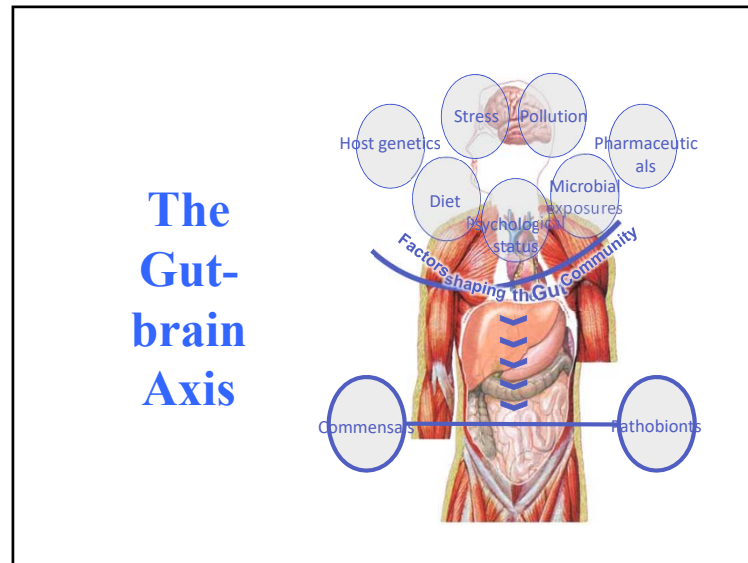
ADHD, Acute Exercise, and Academic Achievement



Pontifex, et al. (2013). *Journal of Pediatrics*, 162, 543-551

ADHD and Diet

- There are no special diets proven to “cure” ADHD or reduce its symptoms.
- There's no evidence that eliminating certain foods has a direct impact on ADHD symptoms.
- All kids can benefit from reducing how much sugar they eat and drink.



Early Gut Bacteria Regulate Happiness

- Scientists have shown that brain levels of serotonin, the 'happy hormone', are regulated by the amount of bacteria in the gut during early life.
- Normal adult brain function depends on the presence of gut microbes during development.
- This research has multiple health implications as it shows that manipulations of the microbiota (e.g. by antibiotics, diet, or infection) can have profound knock-on effects on brain function and mental well-being, including developing microbial-based strategies for treatment for brain disorders.

Exercise Changes Microbiome

- Exercise is associated with altered gut microbial composition, but studies have not investigated whether the gut microbiota and associated metabolites are modulated by exercise training in humans. We explored the impact of six weeks of endurance exercise on the composition, functional capacity, and metabolic output of the gut microbiota in lean and obese adults with multiple-day dietary controls prior to outcome variable collection.
- **METHODS:**
- Thirty-two lean (n=18 [9 female]) and obese (n=14 [11 female]), previously sedentary subjects participated in six weeks of supervised, endurance-based exercise training (3 days/wk) that progressed from 30 to 60 minutes/day and from moderate (60% of heart rate reserve [HRR]) to vigorous intensity (75% HRR). Subsequently, participants returned to a sedentary lifestyle activity for a six-week washout period. Fecal samples were collected before and after six weeks of exercise, as well as after the sedentary washout period, with 3-day dietary controls in place prior to each collection.
- **RESULTS:**
- β -diversity analysis revealed that exercise-induced alterations of the gut microbiota were dependent on obesity status. Exercise increased fecal concentrations of short chain fatty acids (SCFAs) in lean, but not obese, participants. Exercise-induced shifts in metabolic output of the microbiota paralleled changes in bacterial genes and taxa capable of SCFA production. Lastly, exercise-induced changes in the microbiota were largely reversed once exercise training ceased.
- **CONCLUSION:**
- These findings suggest that exercise training induces compositional and functional changes in the human gut microbiota that are dependent on obesity status, independent of diet and contingent on the sustenance of exercise.
- **Exercise Alters Gut Microbiota Composition and Function in Lean and Obese Humans.** Allen JM¹, Mailing LJ¹, Niemi GM¹, Moore R¹, Cook MD¹, White BA¹, Holscher HD^{1,2}, Woods JA^{1,1}, Med Sci Sports Exerc. 2017 Nov 20.

Recommendations

- Get the heart rate up- Martin Gibala
- DO something FUN
- Activity with others
- Get Outside

What kind of exercise? How much?



Arnold School of Public Health
Office for the Study of Aging

JANE BRODY- REFRAME THE MESSAGE

- Stop thinking of future health, weight loss and body image as motivators for exercise.
- FOCUS ON IMMEDIATE-- WELL-BEING AND HAPPINESS AND JOY
- Make Physical Activity THE ELIXIR OF LIFE
- Elderly keep at it with Community, Friendships, and FUN.
- Reduce emphasis on weight loss- studies show even with consistent exercise and BP drops, waist lines shrink, energy is more, but not much weight loss.

USHHS Physical Activity Guidelines for Americans: Adults

■ **150** minutes of moderate intensity physical activity per week

or

■ **75** minutes of vigorous physical activity per week
(In bouts of at least 10 minutes)



Strength Training Twice a Week on Non Consecutive Days



Exerciseanswers.com



tsmethod.com

Intensity Using Heart Rate

- Very light = <50 % of maximal heart rate
- Light = 50-63 % of maximal heart rate
- Moderate = 64-76 % of maximal heart rate
- Vigorous = 77-93 % of maximal heart rate
- Very Hard = >94 % of maximal heart rate
- Maximal = 100% of maximal heart rate

The Copenhagen Consensus Conference 2016

From 4 to 7 April 2016, 24 researchers from 8 countries and from a variety of academic disciplines gathered in Snekersten, Denmark, to reach evidence-based consensus about physical activity in children and youth,

- **THEME 2: PHYSICAL ACTIVITY IN CHILDREN AND YOUTH: COGNITIVE FUNCTIONING**
 - Physical activity and cardiorespiratory fitness are beneficial to brain structure, brain function and cognition in children and youth.
 - Physical activity before, during and after school promotes scholastic performance in children and youth.
 - A single session of moderate physical activity has an acute benefit to brain function, cognition and scholastic performance in children and youth.
 - Mastery of fundamental movement skills is beneficial to cognition and scholastic performance in children and youth.
 - Time taken away from academic lessons in favour of physical activity has been shown to not come at the cost of scholastic performance in children and youth.
- **THEME 3: PHYSICAL ACTIVITY IN CHILDREN AND YOUTH: ENGAGEMENT, MOTIVATION, PSYCHOLOGICAL WELL-BEING**
 - Engagement in physical activity has the potential to positively influence psychological and social outcomes for children and youth, such as self-esteem and relationships with peers, parents and coaches.
 - An autonomy supportive, mastery focused and caring/socially supportive environment, positively influences children's and youths' self-determined motivation, physical activity behaviour and holistic well-being.
 - Close friendships and peer group acceptance in physical activity are positively related to perceived competence, intrinsic motivation and participation behaviour in children and youth.
 - Parental attitudes and behaviours are strongly related to children's and youths' self-perceptions, motivation and physical activity.
 - Systematic and deliberate training enables teachers and coaches to create a positive motivational environment for children and youth.

Intensity Using Heart Rate

- Target Heart rate
 - Maximal heart rate = 220-age
- Based on level of intensity a heart rate range is selected.

Intensity Using the Sing Test

■ Sing Test

■ Low intensity

- You can sing while exercising.

■ Moderate intensity

- You can easily talk while exercising but not sing.

■ Vigorous intensity

- It is difficult to talk while exercising.

