Exercise and the Brain

Why Physical Exercise is Essential to Peak Cognitive Health

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Foreword 1

Exercise and the Brain is interesting and important from many perspectives. Professor Baloh provides a concise overview of the role of physical activity in preventing and treating common neurological symptoms and diseases. The book is also a comprehensive guide to the safety and efficacy of different types of physical activity needed to sustain a healthy brain throughout one's life span. Given the importance of the brain in all human activities, it is surprising that a book from this perspective has not previously been written. *Exercise and the Brain* provides an important step towards elevating the level of awareness of the consequences of different types of activity-related behaviors under a wide range of conditions on the brain and one's health. The level of detail regarding how physical activity can enhance one's functionality in a diseased or healthy state is very impressive. A good example of how things have changed with regard to medical recommendations for exercise is that only a few decades ago patients were told to remain inactive following most surgeries. But today, the recommendation is to begin some type of exercise on the day of surgery, even after major procedures such as hip replacement or heart surgery. This change has evolved as a result of an increased understanding of the biology of exercise.

Another interesting and important feature of the *Exercise and the Brain* is that it is written so that it can be easily appreciated by a very wide audience with respect to their levels of expertise. For example, a rather thorough history of exercise in medicine is addressed. This history is important because it reflects the widely changing views of civilizations and cultures as they have evolved. But generally, there has been a persistent thought by scholars over the course of hundreds of years that the functionality of an individual is dependent to a large extent on their patterns of physical activity. These views are important because they shape important decisions in our educational systems regarding how much and what kind of activity is allotted on a regular basis at different ages. One can imagine a more scientifically based discussion with parents with regard to exercise in the school's curriculum. It is remarkable how varied the opinions differ on the topic of physical activity in sustaining one's health even among the more advanced societies and countries.

In the past, the focus on the biology of exercise was mainly on the cardiovascular and respiratory systems combined with considerations for how to enhance cardiovascular fitness and build muscles. Rarely, did the nervous system, or the endocrine system become a point of interest in developing a greater understanding of one's

functionality. One of the first books that began to reach into the wider range of organ systems when studying the science of physical activity, and particularly the nervous system, was the *Biology of Exercise*, published in 1976. *Exercise and the Brain* is obviously a major and total commitment to begin to understand how activity plays an important role in the control of virtually all organ systems, especially the brain. Advancements in technology is making it more and more possible to monitor organ function during physical activity. There has been a proliferation of sensors that can monitor for long periods multiple cardiovascular, pulmonary, metabolic, and brain biomarkers in awake, fully functional states. These types of measurements can help in monitoring what the patient does outside the clinic. This type of technology of long duration monitoring periods of multiple physiological responses has been focused initially on cardiovascular functions but is potentially applicable to all organ systems including the brain.

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Foreword 2

I first met Dr. Baloh when I was a medical student in 1997. As part of a summer research program in Neurology, I worked on his study about balance disorders in older people and also shadowed him in clinic. I had no idea how much that summer would influence my medical career going forward. What set him apart in my mind, both in the clinical and research settings, is his approach to solving problems. He starts with a deep appreciation for the history of medicine and health in general. He focuses on major issues, takes rigorous steps to evaluate those issues, and lets the findings guide the process. This is why we all need to pay attention to *Exercise and the Brain*. From his nearly 50 years of academic and clinical experience, he concludes: "The brain is uniquely dependent on physical activity for optimal performance and physical activity, whether planned (*exercise*) or part of one's daily routine, can prevent and treat many chronic neurological disorders."

What is unique about *Exercise and the Brain* is that it is the first book to focus on exercise for common neurological symptoms and disorders. In addition, it reviews the history, basic science, and modern-day clinical trial results relevant to exercise and the brain. Dr. Baloh's background and experiences make him the ideal person to tell this story. The book is also unique in the organization of the chapters on key aspects of brain functioning including the developing brain, learning, the aging brain, mental health, chronic pain, cerebrovascular disease, and cognitive functioning. It provides the key historical background—including fascinating stories about exercise and a variety of cultures, including the Hadza, the Ache, Old Order Amish, the Canadian Inuits, the Greek Spartans, and the Romans. It describes the pivotal early scientific studies from Thomas Cureton about the benefits of exercise, Kenneth Cooper (who also identified potential health consequences of extreme exercise), and the Canadian Study of Health and Aging which provided links of exercise with lower risks of Alzheimer's disease. The data from modern-day randomized controlled trials and meta-analyses of these trials is also described in detail.

The emphasis is on scientific data, but the material is presented in a straightforward way that should be understandable to anyone who is interested in improving their brain health.

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Preface

The reason I exercise is for the quality of life I enjoy. (Kenneth Cooper)

Everyone has heard of the health benefits of physical exercise yet so few of us exercise on a regular basis. Are human beings just lazy by nature? Our distant ancestors certainly weren't lazy. They were either physically active or they died. Regular physical activity was required for hunting, gathering, and preparing food and for maintaining shelter. Evolution selected out those who were most physically fit.

In many ancient civilizations, physical fitness was the main attribute for advancement in society. Leaders were selected on the basis of their physical, not their mental, prowess. By contrast, in modern times, physical fitness is less important for survival. People can earn a living without getting out of a chair or leaving the house. In California, people drive to a convenience store a block away from home to purchase food. But our brains were designed (evolved) needing physical activity for best function.

People who exercise regularly have fewer chronic illnesses and live several years longer than people who do not exercise. Furthermore, people who exercise regularly have less anxiety and depression, enjoy life more and have better social interactions than people who do not exercise. Why aren't people getting the message?

Despite all of the advances in neuroscience that have occurred in the last century, physical exercise is still the most effective way to prevent stroke and dementia, two of the main causes of chronic morbidity and mortality in older people. Regular exercise can cut the risk of developing stroke and dementia by as much as 50% and exercise can accelerate recovery from stroke and delay progression of dementia.

Exercise is also effective treatment for numerous other common neurological conditions including movement disorders, chronic low back and neck pain, migraine, fibromyalgia, and balance disorders. It shouldn't be so hard to convince people, particularly older people, to exercise regularly. It is literally a matter of life and death.

What are my credentials to write a book about exercise and the brain? Although my research has not focused on exercise physiology, I have maintained a longstanding interest in the history of medicine, particularly the history of exercise in medicine. As a professor of neurology at UCLA for almost 50 years, I have written and reviewed literally hundreds of research grant proposals submitted to the National Institute of Health (NIH) and private research institutes on a wide range of neurological topics. I have personally supervised several large NIH-funded research

projects that included basic science and clinical components. I recognize the strengths and weaknesses of research studies and understand the limitations of research data. Finally, I have served on countless hospital and departmental committees focused on improving public health and brain health.

In 1990, I submitted a research proposal to the National Institute of Aging entitled *Dizziness in Older People.* The goal was to follow 200 people over the age of 75 with yearly examinations focusing on balance and cognitive function (see Chap. 6). Half of the people complained of balance problems and the other half considered their balance normal. A unique feature of the study was that participants agreed to postmortem examinations of the brain. The proposal was funded and enrolled subjects were followed for a total of 15 years or until death.

At the end of the study, my colleagues and I were struck by the observation that the only participants still alive and well were people who exercised regularly. Since we did not formally measure physical activity levels in the participants and since there may have been other reasons for the correlation between exercise and longevity, we were cautious about conclusions but this chance observation was a key motivating factor for my research into the effect of exercise on the brain and ultimately in writing this book.

I have been an exerciser all of my life, but I must admit that it has become more difficult to exercise as I have gotten older. I was an avid tennis player since childhood and I still recall the satisfaction I experienced after a good singles match. With little effort I pushed myself to exhaustion while enjoying the rhythm of the movement side-to-side, front to back, tracking, and hitting the tennis ball. I looked on my tennis matches as the highlight of my day, anticipating that exhilarating feeling both during and after the match.

But like so many people who participate in sports when young, as I got older it became harder and harder to play a regular tennis schedule without injuries. Then I developed lumbar spinal stenosis and singles tennis was no longer an option. Every time I tried to play a match regardless of how much stretching and warming up beforehand I was left with pain and stiffness for days to weeks after playing.

Playing doubles tennis never appealed to me since there was too much standing around and too little exercise. I tried golf and although I enjoyed the challenge and the camaraderie it provided relatively little exercise for the time spent. Often I felt more stress and frustration after playing golf than before I started.

I needed an exercise routine that I could enjoy and anticipate on a daily basis that would give me all of the health benefits and sense of well-being associated with physical exercise without aggravating my back problem. I settled on a daily routine of 10 min of resistance and stretching exercises followed by brisk walking along the beach for 45 min (intermixed with three brief sprints).

When patients tell me their doctor blamed their symptoms on aging, I cringe and suggest that aging does not cause symptoms, it's the diseases that occur with aging that cause symptoms. Inactivity is the single most important risk factor for developing the common conditions that occur with aging: type 2 diabetes, coronary heart disease, arthritis, chronic pain, stroke, dementia, and balance disorders. Manage these conditions and aging isn't so bad.

This book focuses on the benefits of exercise for prevention and treatment of chronic neurological disorders. It is a guide for finding the right exercise routine for each individual. There is no-one-fits-all approach to exercise.

Many present-day people have little or no early life experience with exercise. When we baby boomers attended school, physical education mostly consisted of playing team sports. Teachers of physical education were invariably coaches, mostly football and basketball coaches, who had little time for the majority of kids who did not excel in team sports. The students who could most benefit from exercise were largely ignored. In college, the emphasis was even more on team sports, you either played team sports or you sat on the sidelines and cheered.

The goal of this book is to show the reader why nearly everyone needs to exercise. There is a strong emphasis on the history of exercise in medicine. As we get older, the need for exercise is even more important since our overall level of routine daily physical activity is less. The brain needs physical activity both for normal health and for preventing and treating diseases common with aging.

How much exercise is needed? As we will see throughout the book there is no-one-fits-all rule with regard to the amount of exercise required. But there are some generalizations that most agree upon. Some is better than none and more is better than less. Start slowly and gradually build up the amount and intensity of exercise over time. The ultimate goal is to improve your physical fitness and this requires an incremental increase in effort.

The key is to make exercise a part of one's daily routine. The beneficial effect of exercise is transient, lasting days to weeks, so it must be a lifelong pursuit. Can we exercise too much? Anything done in excess can potentially be dangerous but with the common sense approach outlined in this book anyone, regardless of underlying health condition, can find some type of exercise that is safe and effective.

The book is divided into three sections. Section 1 (Chaps. 1–3) provides an overview and historical background for understanding why physical activity is so important for normal brain health. Section 2 (Chaps. 3–6) focuses on the importance of physical activity in brain development, learning throughout life and successful aging. Section 3 (Chaps. 7–10) covers the benefits of physical activity for prevention and treatment of common neurological disorders including depression, chronic pain, strokes, and dementia. Finally, I conclude with an overview chapter that summarizes the current World Health Organization (WHO) recommendations for physical activity in children, adolescents, adults, older adults, pregnant women, and patients with disabilities.

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Exercise Is Good Medicine

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Those who think they have no time for bodily exercise will sooner or later have to find time for illness.—Edward Stanley [1]

Although there has been a gradual increase in human longevity over the past few centuries, the improvement in life expectancy has come at the cost of an increased burden of chronic diseases. Some even question whether living longer is worth it if it means suffering through the later years.

Because of the profound effect on all aspects of human behavior and interaction, chronic neurological diseases are the most feared of all chronic diseases. They typically don't kill you, at least not directly, but they can make life unbearable. Although there are currently no simple cures for any of these chronic neurological conditions there is a proven way to delay the onset and decrease symptoms—*increase physical activity.*

Dementia, the most feared of all chronic neurological diseases because of its dehumanizing qualities, is rapidly increasing in frequency as the population ages. Just delaying the onset a few years can markedly decrease the number of people with dementia. Studies show that taking a brisk walk 3 or 4 times a week can delay onset of dementia by as much as 5–10 years.

Physicians and the "Exercise Pill"

Despite the overwhelming scientific evidence that exercise delays the onset of most chronic diseases and improves the quality of life, exercise is clearly underutilized by health professionals. In an editorial entitled *Exercise is medicine and physicians need to prescribe it* published in 2009, Robert Sallis, a family physician at Kaiser Permanente in Southern California and at the time, president of the American College of Sports Medicine, asked two simple questions: "If we had a pill that

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conferred all the confirmed health benefits of exercise, would we not do everything humanly possible to see to it that everyone had access to this wonder drug? Would it not be the most prescribed pill in the history of mankind?" [2].

Why aren't physicians prescribing the "exercise pill" for their patients? Two obvious reasons are: (1) exercise is not a pill, it requires effort and commitment by both physicians and patients and (2) our healthcare system in the United States that incentivizes tests, procedures and drugs does not reward time spent making sure that patients get adequate exercise. The paradox is that it costs at least $1500 per year more to care for a patient who is physically *in*active compared to a patient who is physically active.

Cardiologists have done a reasonably good job of including exercise in the management of their patients with heart disease. A discussion of the role of exercise in maintaining heart health is often included in a routine examination. Exercise is now a part of cardiac rehab after heart attacks, stent placement and by-pass surgery. Patients intuitively understand that exercise is important for heart muscle function.

But the role of exercise in brain function is less intuitively obvious. Discussions of the role of exercise in brain health is not a part of most routine neurological assessments even though there is compelling evidence that exercise decreases the risk of stroke, helps maintain balance and prevent falls with aging, and improves cognition and delays the onset of dementia with aging. Equally important, exercise is critical for brain development in children and for learning throughout life.

Exercise, Physical Activity and Physical Fitness

The terms physical activity and exercise are often used interchangeably but it is important to note at the onset that these terms are not exactly the same thing. Physical activity refers to any movement requiring energy expenditure beyond the resting level including manual labor, housework or walking to and from the grocery store whereas exercise is a planned physical activity with the goal of maintaining or improving physical fitness and health [3].

As a rule, physical activity regardless of whether planned or the result of daily routine provides the same benefits for both physical fitness and health. The obvious implication is that people who regularly perform manual labor do not need to exercise as much as people who have a desk job. Indeed, before the industrial revolution most people had a high level of daily physical activity and did not need to exercise.

Physical fitness, on the other hand, represents a combination of personal attributes including cardiovascular fitness, muscle strength and endurance, body composition, balance and agility. Exercise, physical activity and physical fitness are interrelated but there are multiple factors that influence physical fitness in addition to exercise and physical activity such as genetic variants, health status and age. One way to think of physical fitness is the ability to carry out daily tasks with vigor and alertness without undo fatigue. It can be a rough estimate of one's physical activity over the past several months. Of the various attributes that make up physical fitness, cardiovascular fitness has the largest impact on overall health particularly on chronic age-related diseases.

Exercise for Health in Early America

In eighteenth century America, the routine practice of medicine was primitive still based on ancient concepts of humors and vital spirits. Lifestyles were largely agricultural and most people had a heavy dose of physical activity, plowing fields, hunting wild animals and herding domestic animals. Transportation was mainly through walking and horseback riding. Although some physicians were aware of the benefits of exercise in maintaining health, this information was not routinely conveyed to patients who wanted medicines to treat their ills.

At the turn of the nineteenth century, several American physicians warned that aggressive treatments such as blood letting, drugging and purging were ineffective and potentially dangerous and that medical practitioners should reconsider the healing powers of nature espoused by Hippocrates and Galen. The Greek term "physis" means natural or nature and was the root for "physick", the word used for medicine in the eighteenth Century, and for the term "physician".

The value of physical activity for prevention and treatment of disease was invigorated when a New York physician, Shadrach Ricketson, published a book in 1806 entitled *Means of Preserving Health and Preventing Disease.* Ricketson espoused that a sedentary lifestyle whether by choice or employment enfeebled the body making it susceptible to disease. He argued that: "idleness and luxury create more diseases than labour and industry" [4].

One of the most prominent American surgeons in the nineteenth century, John Collins Warren, best known for the introduction of ether anesthesia into the surgical theater, played a critical role in the birth of the nation's fledgling physical education movement. Warren studied abroad, obtaining his medical degree at the University of Edinburgh in 1801 and returned to Boston where he joined his father, also a well known surgeon, in practice. After his father's death in 1815, Warren assumed the Hersey Professorship in Anatomy and Surgery at Harvard University where he served as the first dean of the Harvard Medical School and was a founding member of the Massachusetts General Hospital.

Throughout his career, Warren had a keen interest in exercise and in 1845 he published *Physical Education and Preservation of Health* in which he argued that there must be a balance between intellectual and physical education. Warren emphasized that exercise must begin in early childhood and continue throughout life if one hopes to maintain good health into old age. He noted that children were not meant to be still for long periods of time and that parents should not force them to spend long hours studying without breaks for physical activity. They should be allowed to spend several hours playing without structure and they should not spend more than 6–7 h a day in a classroom.

The risk of emphasizing classroom studies over exercise was the development of a "delicate constitution" that led to increased susceptibility to illness [5]. Like most male physicians of his time, Warren considered girls to be the "weaker sex" with a hyperactive nervous system that was particularly vulnerable to extended periods of intellectual activity without breaks. He warned that literary pursuits could be destructive to the health of young women. He was particularly concerned about the effect on the young lady's posture of long hours "slumping" over a desk reading or writing.

For girls, Warren recommended walking outside in the open air, erect not looking at the ground, and dancing in small groups stimulating muscles of the body and lower limbs giving them grace and power. To exercise the upper extremities he suggested the girls swing on a bar suspended from the ceiling with ropes, the "triangle". For boys, he recommended going to a gymnasium for a minimum of 2 h of physical activity a day.

Exercise and Early Neurology

One of the founding fathers of American Neurology, S. Weir Mitchell, had a lifelong interest in exercise and repeatedly emphasized the importance of regular physical activity for maintaining good mental health. Mitchell grew up, was educated and practiced medicine in Philadelphia where he specialized in treating women with neurasthenia, a common neuropsychiatric diagnosis at the time. Mitchell developed his interest in Neurology while working with soldiers with nerve and brain injuries during the American civil war.

In the 1880s, Mitchell published two best selling books for the lay public: *Wear and Tear, or Hints for the overworked* and *Fat and Blood: An Essay on the Treatment of Current Forms of Neurasthenia and Hysteria.* In *Wear and Tear,* Mitchell summarized his misogynistic views on women's mental health shared by most neurologists of the time [6]. Although both men and women were susceptible to neurasthenia, women were particularly susceptible because of their weak constitution. Mitchell felt that young girls between the age of fourteen and eighteen were at particular risk and that it was probably best not to try to educate girls in that age range. Their limited energy was best directed towards developing skills required for their future roles as wives and mothers rather than being wasted on mental pursuits. Physical activity was limited to that received during their household chores.

In *Fat and Blood,* Mitchell described his famous "rest cure" for women with neurasthenia [7]. The women were sequestered from their family to prevent interference and were confined to bed for 6–8 weeks. Twice a day in the morning and evening they were lifted onto a bedside lounge where they stayed while their bed was remade. Throughout the day they were constantly fed great amounts of high fat foods including two gallons of milk. This was done to restore the "fat and blood" that was presumably depleted by stress and overwork.

The cruelest part of the treatment was that they were prohibited from reading, writing or performing any type of intellectual activity. Not even manual tasks such as sewing or crocheting were permitted. In place of physical activity they received massages and electrical stimulation of their muscles, considered "passive exercise".

Paradoxically, Mitchell repeatedly emphasized the importance of regular physical activity for good mental health particularly for his women patients with neurasthenia [8]. He suggested that one potential benefit of the rest cure was that it made women eager to return to normal physical activities including exercise. Mitchell even resorted to extreme methods to force his women patients out of bed to exercise. For example, on one occasion he drove a patient half way home where he left her to walk the rest of the way on her own.

Mitchell noted that men with neurasthenia didn't do so well with his rest cure so for them, which included Teddy Roosevelt and Walt Whitman, he recommended the "West cure", sending them to visit the western part of the United States to engage in vigorous physical activity and to write about their experiences.

Early Ideas on Physical Education

In 1887, J William White, another Philadelphia physician, published an article for the Lippincott's magazine lauding the benefits of exercise for acquiring and maintaining good health that had a major impact on American physicians at the turn of the century. White was a well respected surgeon and an avid sportsman who joined the faculty of the University of Pennsylvania Medical School in 1874. He loved to sail and in 1880 he swam the cold, rough ocean from Newport to Narragansett Rhode Island making the 10 mile swim in 5 h and 40 min. White wrote that exercise was "by far the most important therapeutic and hygenic agency at the command of the physician" and that it was as good "as any of the drugs of the pharmacopeia." [9].

By the end of the nineteenth century, all states mandated instruction in the "Laws of Health" (physical education) in public schools. Two books published in the first decade of the twentieth century nicely summarized the new emphasis of physical fitness in maintaining good health.

In 1904, Harvard physician Dudley Sargent published *Health, Strength and Power* based on his experience with physical education programs at several colleges [10]. After graduating from Bowdoin College in 1875, Sargent became an instructor in gymnastics at Yale College and in the same year opened his own private gymnasium in New York. A year later he was appointed assistant professor of physical training and head of the Hemenway Gymnasium at Harvard University. Sargent recognized the need for trained teachers in the field of physical education and he developed a gymnasium in Cambridge that ultimately became the Sargent School of Physical Education. He also organized courses in physical education training at Harvard University summer school which he personally taught until 1919.

In 1909, University of Pennsylvania physician and medical educator, R. Tait McKenzie published *Exercise in Education and Medicine* in which he emphasized the importance of teaching physical education to medical students and medical practitioners. He pointed out that "Exercise and massage have been used as remedial agencies since the days of Aesculapius, but definite instruction in their use has seldom been given to medical students." [11].

As with most of his fellow physicians, McKenzie divided exercise into two categories: active that required exertion of will-power and passive that did not require exertion of will-power, both important for treating disease. Physicians used a variety of passive exercises at the time (massage, muscle stretching by hand or machine, electrical stimulation of nerves and muscles) and McKenzie noted that passive exercise had the advantage of being restful, not exhausting an over-wrought brain. He warned that physicians often preferred "the administration of pill or draught to purge the system" rather than the use of normal muscular activity.