

Successful Aging of Individuals with Brain Injury

by Paul F. Aravich, Ph.D. and Anne H. McDonnell, MPA, OTR/L

Successful aging is a goal for all creatures great and small. This is true for the lowly mayfly living one day and for the inspiring---if not scrawny---bristlecone pine tree living 4000 years. However, successful aging in people requires more than longevity: it requires the maintenance of physical, cognitive and social function (Rowe and Kahn 1997). The number of older people has increased dramatically throughout most of the world. Declining death rates have been accompanied by advances in long-term medical care, rehabilitation and social support making the prospects for successful aging an ever increasing reality for everyone, including survivors of traumatic brain injury (TBI), who are living longer than ever before.

Only a few studies have looked at mortality rates and the primary causes of death in long-term TBI survivors (Trudel, Felicetti and Mozzoni, 2005). Mortality rates have been estimated to be nearly four times greater than those for people without TBI (Baguley et al., 2000). Even mild TBI is associated with a small but statistically significant reduction in long-term survival (Brown et al., 2004). Overall life expectancy may be reduced by 7 years in survivors, who are twice as likely to die as age, gender and ethnically matched controls; the best predictors of premature death were older age, lack of employment at the time of injury, and disability at the time of rehabilitation discharge (Harrison-Felix et al., 2004). The limited data available suggest that long-term survivors have increased death rates from circulatory and respiratory diseases, as well as from seizures and choking (Shavelle et al., 2001). Last but not least, TBI increases the risk of Alzheimer's disease (Lye and Shores, 2000). Compared to seizures and choking, much less attention has focused on cardiovascular, respiratory and brain fitness in long-term survivors, despite the importance of each for successful aging. It follows that the promotion of successful aging in long-term survivors requires attention to factors that go beyond the brain injury itself.

Contrary to popular belief, aging is not a disease. In fact, it can be argued that aging starts at conception and then continues across various developmental life stages. Instead of aging, we fear senescence: a progressive loss in the ability to maintain fitness and defend against death (Williams, 1999). The causes of senescence are both biological and environmental. But environmental and lifestyle factors play a more important role in successful aging than genetic factors. More research is needed to identify the modifiable environmental and lifestyle factors

that are unique to long-term survivors. This requires a leap beyond the simple biology of brain injury and a greater understanding of the biopsychosocial model of successful aging.

As greater longevity is sought for survivors, it is important to avoid the Tithonus error: quantity rather than the quality of life (Bunk, 2002; Williams, 1999). Clearly, the goal for successful aging in survivors is to compress morbidity not to expand it.

The following 10 rules are designed to promote successful aging in TBI survivors. They build upon the Alzheimer Association's effort to potentially avoid Alzheimer's disease (Alzheimer's Association, 2004).

Rule 1. Take Care of the Survivor's Heart. It is now clear that several cardiovascular risk factors are also Alzheimer's disease risk factors, including diabetes, hypertension, and an adverse lipid profile (Alzheimer Association, 2004). Another cardiovascular disease risk factor is obesity. Since TBI survivors have an already increased risk for Alzheimer's disease, survivors with diabetes, hypertension or an adverse lipid profile compound that risk at the same time they increase their risk for heart disease and stroke. Clearly, the promotion of successful aging in TBI survivors requires a focus that goes beyond the brain and includes the early diagnosis and treatment of cardiovascular risk factors.

Rule 2. Exercise the Survivor's Body. Successful aging is importantly related to lifestyle factors such as exercise (Surgeon General's Report, 1996). There is little doubt that physical fitness protects against the three leading causes of death in North America: heart disease, cancer and stroke. It is also clear that moderate exercise promotes respiratory fitness and, by improving balance can reduce the risks of falls in survivors (Dault and Dugas, 2002). Moderate exercise also elevates mood, improves cognitive scores and, at least in adult rats, increases the number of neurons in an area of the brain linked to learning and memory and frequently injured by TBI (Grealy et al., 1999; Rolland et al., 2000). Regular movement also reduces the risk of deep venous thrombus (DVT) formation and premature death from pulmonary thromboembolism. Greater attention must focus on the fact that exercise is not just for rehabilitation; it is also for the promotion of successful aging. Innovative ways to overcome the limitations of TBI include combining exercise with the virtual reality of traveling through an exotic environment in survivors with attention deficits (Grealy et al., 1999) and the use of rhythmic music patterns (Hurt et al., 1998).

Rule 3. Exercise the Survivor’s Brain. While there is considerable interest in the promotion of physical fitness, less attention has been paid to what is known as “brain fitness.” Neuroscientists say, “If you don’t use it you lose it,” or, “Neurons that fire together wire together.” There is good evidence that cognitively stimulating activities protect against Alzheimer’s disease (Alzheimer’s Association, 2004), which is a particularly important issue for survivors at increased risk for Alzheimer’s. Life-long, cognitively stimulating activities maximize brain fitness and promote successful brain aging; it can be argued that neuroscience research supports club houses, specialized recreational camps, job training, education programs, better housing, and respite care programs to promote brain fitness in survivors and caregivers alike. More innovative strategies building on the principles of music therapy (White, 2001), art therapy (Rentz, 2002), dance therapy (Pratt, 2004), virtual reality therapy (Lee et al., 2003), and theater arts (Noice et al., 2004) are clearly needed to exercise the brains of survivors and caregivers.

Rule 4. Feed the Survivor’s Brain. Nutrition is critically related to successful aging. Despite this, a substantial number of survivors routinely consume poor diets. The 2005 U.S. Dietary Guidelines (Dietary Guidelines, 2005) clearly state that sugar and highly refined carbohydrate (e.g., white flour) should be avoided along with the consumption of saturated-fatty acids and of the trans-fatty acids found in many snacks, pastries and candy bars. In some studies, saturated- and trans-fatty acid consumption increased the risk of Alzheimer’s disease (Morris et al., 2003). And, in rats, high-fat/high-sugar diets worsen the cognitive effects of experimental brain injury (Wu et al., 2003).

The 2005 U.S. Dietary Guidelines also recommend consuming a diet high in whole grains, vegetables and fruits. Each of these is rich in essential nutrients and antioxidant compounds and linked to reduced risks of cardiovascular disease, cancer and stroke.

Good nutrition is also important for immunity and essential for cognitive function; B-vitamin deficiencies, dehydration, and protein-energy malnutrition impair cognition. Diets that follow the U.S. Dietary Guidelines are sufficient to protect against these deficiencies, though it has been recommended that all adults should take a daily multivitamin (Fletcher and Fairfield, 2002)

There is also good evidence supporting Mediterranean type diets, which are associated with increased whole grain, vegetable, fruit, and olive oil consumption. The Lyon Diet, an atypical Mediterranean diet that uses canola oil instead of olive oil, has been shown to be especially effective for coronary heart disease. Such a dietary approach may be especially helpful in

survivors because of their potentially increased risk of cardiac death. And, it may be especially important for survivors if cardioprotective approaches are also Alzheimer's protective approaches.

A heart healthy diet, which is also a brain healthy diet, should also include regular fish consumption. The American Heart Association recommends two servings of fatty fish consumption per week (Kris-Etherton et al., 2002). Fatty fish are rich in various nutrients, including the omega-3 fatty acids (fish oils); one serving of canned salmon yields about a gram of these fatty acids (Kris-Etherton et al., 2002). Shorter chain omega-3 fatty acids are found in flaxseed, walnuts, soybeans and canola oil. In addition to its cardiovascular and stroke benefits, dietary omega-3 fatty acid intake is associated with a reduced risk for Alzheimer's disease (Morris et al., 2003), potential benefits on the mood disorders (Freeman, 2000), and the promotion of neural plasticity.

Rule 5. Promote Mental Health in the Survivor. Successful aging is importantly related to mental health as well as to physical health. In 2001 there were 51% more suicides than homicides in the United States (Arias et al., 2003). Suicide has been called "the silent epidemic" and, according to the Brain Injury Association of America, accounts for 2/3 of all TBI firearm deaths. Mental illnesses, such as depression, bipolar disorder and schizophrenia, are major risk factors for suicide and increase the risk of a TBI by 70% (Fann et al., 2002). Depression is also a risk factor for Alzheimer's disease (Green et al., 2003). It is obvious that a pre-injury mental illness does not magically disappear post-injury. Even without a pre-injury illness, once a TBI occurs, the lifetime risk of depression is increased by 54% (Holsinger et al., 2002). Even a mild TBI dramatically increases the risk of a mental illness within 6 months (Fann et al., 2004). Undeniably, psychiatric disorders negatively impact successful aging by affecting cognition, emotion and the general quality of life. It is also clear they impact cardiovascular and brain fitness.

Glucocorticoid stress hormones are elevated in a variety of psychopathologies, including depression, bipolar disorder and post traumatic stress disorder (Sapolsky, 2000). The issues of loss and social isolation, together with the psychological burden of finding adequate housing, education and transportation are themselves other significant stressors. Regardless of its causes, a mental illness like depression not only compromises rehabilitation in the survivor, it also impairs successful aging by reducing quality of life and increasing the risk of cardiovascular

disease and Alzheimer's disease. Consequently, the importance of early and aggressive mental health interventions in survivors, the battle to reduce the stigma against mental illness, and the battle for health insurance parity for mental health coverage are imperatives for the promotion of their successful aging.

Rule 6. Avoid Tobacco, Alcohol and Other Drugs of Abuse in the Survivor. Chemical dependency is yet another factor that impairs successful aging in survivors. And, like mental illness, it causes brain injury. It has been estimated that 57% of TBI's were pre-injury heavy drinkers (Kolakowsky-Hayner et al, 1999) and it is clear that alcoholism interferes with TBI recovery. While there is considerable interest in its potential health benefits, excessive alcohol exacerbates the cortical atrophy associated with normal brain senescence, is related to Wernicke's encephalopathy and Korsakoff's dementia, and adversely affects the heart (Oscar-Berman and Marinkovic, 2003; Spies et al., 2001). Recent data suggest that, the equivalent of 2 drinks per day elevated the risk of dementia, (Mukamal et al., 2003). Hence, the individual with alcoholism and TBI takes a double-hit for Alzheimer's disease risk.

However, tobacco is the most deadly drug: According to the U.S. Centers for Disease Control and Prevention it kills more Americans than alcohol, the so-called illegal drugs, murders, suicides, traffic accidents and AIDS combined. It is a major risk factor for heart disease and stroke and is highly correlated with lung cancer and chronic obstructive lung diseases such as emphysema. Cardiovascular and respiratory fitness are important issues for aging survivors.

It is important to remember that all of the drugs of abuse affect the reward circuitry of the brain, and once this circuit is injured, it is difficult for the chemically dependent person to just say no.

Rule 7. Avoid Social Isolation in the Survivor. It has been said, "The human brain is a social brain." Fundamental human emotions such as love and laughter depend importantly upon social and physical contact with others. Successful aging, by definition, involves social engagement (Rowe and Kahn, 1997) and, at least in the rat, social factors impact neuroplasticity (Lu et al., 2003). Animal research shows that social isolation causes physical injury to the brain and is associated with cognitive and emotional deficits (Whitaker-Azmitia et al., 2000). Social isolation in a mouse model of Alzheimer's disease also increases the expression of certain markers for the disease (Dong et al., 2004). Social isolation inhibits successful aging in the TBI survivor and is yet another pathology superimposed on brain senescence. From this perspective,

social enrichment relates to more than the humane care and treatment of the survivor; it is an essential feature for brain fitness and an essential requirement for successful aging in both the survivor and the caregiver.

Rule 8. Protect the Survivor's Brain. While the human brain is one of the most miraculous things in the universe, it is also among the most fragile. A brain injury is terrible, but a preventable brain injury is much worse. Greater enforcement of helmet use during motorcycling, biking, skateboarding, rollerblading, skiing, and snowboarding is needed, as is regular seat belt use. As individuals with TBI reside in more community-based programs, providers must be educated about the vulnerability of their brains to a second impact and appropriate precautions must be taken. Importantly, while the overall TBI death rate is declining, the fall-induced TBI death rate in older people is actually increasing (Adekoya et al., 2002). So protection of the brain goes beyond personal protective equipment and includes regular fall assessments in older people and in people with disabilities (Chang et al., 2004).

Protection of the brain also involves letting it sleep. The driving skills of sleep-deprived people are similar to those who are intoxicated with alcohol (Arnedt et al., 2001). Sleep deprivation related to lifestyle issues and to various pathologies (Roehrs and Roth, 2004) also impairs impulse control, cognition, mood, attention, abstinence from drugs of abuse, and immune function (Working Group Report on Problem Sleepiness, 1997). Recent data indicate that more sleep disturbances occur in survivors with mild TBI than those with severe TBI (Mahmood et al., 2004).

Rule 9. Form More Partnerships for Individuals with TBI. It is obvious that there should be close partnerships between brain injury, Alzheimer's disease and mental health professionals. TBI can cause behavioral and psychiatric symptoms that are distinct from those associated with mental illnesses, and injury to the prefrontal lobes often impairs the empathy and bonding necessary for psychotherapy; these problems are not unlike the behavioral and psychiatric problems associated with the irreversible dementias. Mental health, TBI and Alzheimer advocacy groups have overlapping issues regarding lack of services, respite care, social isolation, guardianship, end of life issues, stigma, and the impairment of successful aging.

Rule 10. Look for Greatness in Each Person. The human brain is the last frontier of science: we will know more about parallel universes, colliding galaxies and black holes long before we understand the universe between our ears. The following four variables from Brain Facts (2002)

combine to demonstrate the uniqueness and possibilities of this universe. Variable 1: The human brain has about as many neurons as there are stars in the Milky Way Galaxy (over 100 billion). Variable 2: Under normal circumstances, there are 10 times as many cells called glia cells, which play a supportive role in the nervous system and, following injury, can contribute to its secondary complications. Variable 3: Each neuron makes connections with thousands of other neurons over small spaces called synapses. Variable 4: Remarkably, the synaptic connections change each time we do something, experience something or learn something. This continuing, unrelenting reorganization of the brain is called neural plasticity; another name for neural plasticity is hope; and another name for hope is research.

Two conclusions follow from the summation of these four variables. The first is that every person, brain injured or not, has a magnificent and unique brain. The second is that there are an infinite number of possible synaptic connections in all of our brains, injured or not. The organization of the human brain has limitless possibilities. Gerthe says “you see what you look for.” If you look for greatness in survivors, you will see it. If you look for greatness in caregivers, you will see it. If you look for greatness in other professionals, you will see it. Importantly, what you look for you measure, you validate, you fight for, and you implement. Look beyond the biology of brain injury and beyond the field of TBI. Look for the multidisciplinary, biopsychosocial promotion of successful aging in survivors and caregivers.

About the Authors

Paul F. Aravich, Ph.D., is a neuroscientist and Associate Professor in the Department of Pathology and Anatomy and the Glennan Center for Geriatrics and Gerontology at Eastern Virginia Medical School, Norfolk, VA 23507. He is Chair of the Virginia Brain Injury Council, and a member of the Governor’s Public Guardian and Conservator Advisory Board, the National Alliance for the Mentally Ill of Virginia, the Southeastern Virginia Chapter of the Alzheimer’s Association, and the Society for Neuroscience. His research interests are on nutrition, exercise and the brain.

Anne McDonnell, MPA, OTR/L, is Executive Director of the Brain Injury Association of Virginia. She has over 20 years of experience in brain injury rehabilitation across a continuum of hospital and community based settings, holds a clinical faculty position in the School of Occupational Therapy at Virginia Commonwealth University, and co-authored Virginia’s guide for serving children with brain injury in the public schools. She is interested in increasing public awareness of brain injury, expanding community based service options for survivors, and education of survivors, caregivers and professionals.

References

- Adekoya N, Thurman DJ, White DD et al.: Surveillance for traumatic brain injury deaths--United States, 1989-1998. *MMWR Surveill Summ* 51(10):1-14, 2002.
- Alzheimer Association: Think About Your Future. Maintain Your Brain™ Today. Available on the World Wide Web at: <http://www.alz.org/maintainyourbrain/overview.asp>. Accessed December 28, 2004.
- Arnedt JT, Wilde GJ, Munt PW et al: How do prolonged wakefulness and alcohol compare in the decrements they produce on a simulated driving task? *Accid Anal Prev* 33(3):337-44, 2001.
- Arias E, Anderson RN, Kung HC et al: Deaths: final data for 2001. *Natl Vital Stat Rep* 52(3):1-115, 2003.
- Baguley I, Slewa-Younan S, Lazarus R et al: Long-term mortality trends in patients with traumatic brain injury. *Brain Inj* 14(6):505-512, 2000.
- Brain Facts: A Primer on the Brain and Nervous System*. Washington: Society for Neuroscience, 2002.
- Brown AW, Leibson CL, Malec JF et al.: Long-term survival after traumatic brain injury: a population-based analysis. *NeuroRehabilitation* 19(1):37-43, 2004.
- Bunk S: The molecular face of aging. *The Scientist* 6(10):16-18, 2002.
- Chang JT, Morton SC, Rubenstein LZ et al.: Interventions for the prevention of falls in older adults: systematic review and meta-analysis of randomised clinical trials. *BMJ* 328(7441):680, 2004.
- Dault MC and Dugas C: Evaluation of a specific balance and coordination programme for individuals with a traumatic brain injury. *Brain Inj* 16(3):231-44, 2002.
- Dietary Guidelines: *Dietary Guidelines for Americans 2005*. Washington: U.S. Departments of Health and Human Services and Agriculture, 2005.
- Dong H, Goico B, Martin M et al.: Modulation of hippocampal cell proliferation, memory, and amyloid plaque deposition in APPsw (Tg2576) mutant mice by isolation stress. *Neuroscience* 127(3):601-609, 2004.
- Fann JR, Burington B, Leonetti A et al.: Psychiatric illness following traumatic brain injury in an adult health maintenance organization population. *Arch Gen Psychiatry* 61(1):53-61, 2004.
- Fann JR, Leonetti A, Jaffe K et al.: Psychiatric illness and subsequent traumatic brain injury: a case control study. *J Neurol Neurosurg Psychiatry* 72(5):615-620, 2002.
- Fletcher RH and Fairfield KM: Vitamins for chronic disease prevention in adults: clinical applications. *JAMA* 287(23):3127-3129, 2002.
- Freeman MP: Omega-3 fatty acids in psychiatry: a review. *Ann Clin Psychiatry* 12(3):159-165, 2000.
- Grealy MA, Johnson DA and Rushton SK: Improving cognitive function after brain injury: the use of exercise and virtual reality. *Arch Phys Med Rehabil* 80(6):661-667, 1999.
- Green RC, Cupples LA, Kurz A et al.: Depression as a risk factor for Alzheimer disease: the MIRAGE Study. *Arch Neurol* 60(5):753-759, 2003.
- Harrison-Felix C, Whiteneck G, DeVivo M et al.: Mortality following rehabilitation in the Traumatic Brain Injury Model Systems of Care. *NeuroRehabilitation* 19(1):45-54, 2004.
- Holsinger T, Steffens DC, Phillips C et al.: Head injury in early adulthood and the lifetime risk of depression. *Arch Gen Psychiatry* 59(1):17-22, 2002.
- Hurt CP, Rice RR, McIntosh GC et al.: Rhythmic Auditory Stimulation in Gait Training for Patients with Traumatic Brain Injury. *J Music Ther* 35(4):228-241, 1998.
- Kolakowsky-Hayner SA, Gourley EV 3rd, Kreutzer JS et al.: Pre-injury substance abuse among persons with brain injury and persons with spinal cord injury. *Brain Inj* 13(8):571-578, 1999.
- Kris-Etherton PM, Harris WS and Appel LJ; American Heart Association. Nutrition Committee: Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. *Circulation*. 2002, 106(21):2747-2757. Erratum in: *Circulation* 107(3):512, 2003.
- Lee JH, Ku J, Cho W et al.: A virtual reality system for the assessment and rehabilitation of the activities of daily living. *Cyberpsychol Behav* 6(4):383-388, 2003.
- Lu L, Bao G, Chen H et al.: Modification of hippocampal neurogenesis and neuroplasticity by social environments. *Exp Neurol* 183(2):600-609, 2003.
- Lye TC and Shores EA: Traumatic brain injury as a risk factor for Alzheimer's disease: a review. *Neuropsychol Rev* 10(2):115-129, 2000.
- Mahmood O, Rapport LJ, Hanks RA et al.: Neuropsychological performance and sleep disturbance following traumatic brain injury. *J Head Trauma Rehabil* 19(5):378-390, 2004.
- Morris MC, Evans DA, Bienias JL et al.: Consumption of fish and n-3 fatty acids and risk of incident Alzheimer disease. *Arch Neurol* 60(7):940-946, 2003.
- Mukamal KJ, Kuller LH, Fitzpatrick AL et al.: Prospective study of alcohol consumption and risk of dementia in older adults. *JAMA* 289(11):1405-1413, 2003.

Noice H, Noice T and Staines G: A short-term intervention to enhance cognitive and affective functioning in older adults. *J Aging Health* 16(4):562-585, 2004.

Oscar-Berman M and Marinkovic K: Alcoholism and the brain: an overview. *Alcohol Res Health* 27(2):125-133, 2003.

Pratt RR: Art, dance, and music therapy. *Phys Med Rehabil Clin N Am* 15(4):827-41, 2004.

Rentz CA: Memories in the making: outcome-based evaluation of an art program for individuals with dementing illnesses. *Am J Alzheimers Dis Other Demen* 17(3):175-181, 2002.

Roehrs T and Roth T: Sleep disorders: an overview. *Clin Cornerstone* 6(Suppl 1C):S6-S16, 2004.

Rolland Y, Rival L, Pillard F et al.: Feasibility of regular physical exercise for patients with moderate to severe Alzheimer disease. *J Nutr Health Aging*. 4(2):109-113, 2000.

Rowe JW and Kahn RL: Successful aging. *Gerontologist* 37(4):433-440, 1997.

Sapolsky RM: Glucocorticoids and hippocampal atrophy in neuropsychiatric disorders. *Arch Gen Psychiatry* 57(10):925-935, 2000.

Shavelle RM, Strauss D, Whyte J et al.: Long-term causes of death after traumatic brain injury. *Am J Phys Med Rehabil* 80(7):510-516, 2001.

Spies CD, Sander M, Stangl K et al.: Effects of alcohol on the heart. *Curr Opin Crit Care* 7(5):337-343, 2001.

Surgeon General's Report: *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: U.S. Dept of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996.

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Wu A, Molteni R, Ying Z et al.: A saturated-fat diet aggravates the outcome of traumatic brain injury on hippocampal plasticity and cognitive function by reducing brain-derived neurotrophic factor. *Neuroscience* 119(2):365-375, 2003.

Whitaker-Azmitia P, Zhou F, Hobin J et al.: Isolation-rearing of rats produces deficits as adults in the serotonergic innervation of hippocampus. *Peptides* 21(11):1755-1759, 2000.

Williams GC: The 1999 Crafoord Prize lectures. The Tithonus error in modern gerontology. *Q Rev Biol* 74(4):405-415, 1999.

Working Group Report on Problem Sleepiness. National Center on Sleep Disorders Research and Office of Prevention, Education, and Control. National Heart, Lung and Blood Institute. National Institutes of Health, 1997. Available on the World Wide Web at: http://www.nhlbi.nih.gov/health/prof/sleep/pslp_wg.pdf. Accessed December 28, 2004.