Open Access

OBM Geriatrics

Perspective

Behavioural and Complementary Interventions for Healthy Neurocognitive Aging

Robert L. Conder, Jr. [1, †, *], Christopher Friesen [2, †], Alanna A. Conder [1, †]

1. Carolina Neuropsychological Service, Raleigh, NC, USA; E-Mails: bconder10@gmail.com; aconder14@gmail.com
2. Niagara Neuropsychology, Grimsby, Ontario, Canada; E-Mail: dr.cfriesen@gmail.com

† These authors contributed equally to this work.

* **Correspondence:** Robert L. Conder, Jr.; E-Mail: bconder10@gmail.com

Academic Editor: Kamen Tsvetanov

Special Issue: Health Modifiers of Neurocognitive Aging

OBM Geriatrics
2019, volume 3, issue 1
doi:10.21926/obm.geriatr.1901039

Received: November 30, 2018
Accepted: March 18, 2019
Published: March 20, 2019

Abstract

***Background*:** While the percent of persons 65 and older is expected to increase to 17% of the world's population by 2050, this increase in longevity does not necessarily suggest a parallel increase in health status. While aging is an inevitable aspect of living, there are factors which can accelerate morbidity and mortality, as well as factors likely to promote a healthy transition into longevity. This paper addresses behavioural and complementary interventions for healthy neurocognitive aging. Specific evidence-based cardiovascular exercise guidelines, sleep hygiene strategies to improve restorative sleep, and dietary modifications to improve brain and heart health are reviewed. Also reviewed are neurofeedback and brain brightening neuromodulation interventions to limit mental declines often associated with aging. Research evidence tying behavioural and complimentary treatment interventions to improved outcomes in older persons with Alzheimer's and other dementias is also presented.

***Methods*:** Evidence based perspective paper offered on the basis of clinical neuropsychological experience and review of relevant research literature.
***Results*:** Evidence-based practice guidelines and research studies addressing behavioral and complementary interventions to support healthy neurocognitive aging were reviewed. Mounting research evidence reviewed herein supports identification of Exercise, Sleep and Diet/Nutrition as core health modifiers for healthy neurocognitive aging. Easy to adopt behavioural interventions as well as some innovative treatment interventions were reviewed to delay or minimize the normal physical and mental decline often associated with aging. Adjunct activities and interventions such as neurofeedback, neuromodulation, sauna and supplements being investigated also show some promise for healthy neurocognitive aging.
***Conclusions*:** Normal aging does not inevitably portend acquisition of chronic health problems and faltering mental acuity. As we have attempted to show, avoidance of certain unhealthy habits and behaviors and adoption of healthy habit and behavioural alternatives can foster good mental and neurocognitive health throughout the lifespan.

Keywords
Aging; neurocognition; health; exercise; sleep; diet; neurofeedback; neuromodulation

1. Introduction

Worldwide, the population age 65 and older is growing exponentially [1]. The percent of persons 65 and older is 8.5 percent and is expected to increase to 17% of the world's population by 2050, with the oldest adults living in North American and Europe. However, this increase in longevity does not necessarily suggest a parallel increase in health status. Additionally, for the current middle age population, life expectancy is shorter than that of current older adults. How can this be in a time of advances in medical care, diagnosis and treatment, and pharmaceuticals?

While aging is an inevitable aspect of living, there are factors which can accelerate morbidity and mortality, and factors likely to promote a healthy transition into longevity. Rates of childhood obesity are skyrocketing [2]. The cause is multifactorial. School systems are reducing emphasis on physical fitness and health due to financial cost and ostensibly a need for more classroom time to help students pass standardized tests [3]. Food companies spend billions of dollars marketing unhealthy foods to children, especially with Saturday morning cartoons and children's programming [4]. The rise in social media and computerized devices has increased sedentary behaviour and perhaps altered both healthy physical and cognitive development in children and adolescents [5]. Unfortunately, many of these sedentary and overweight children become pre-diabetic and pre-metabolic young adults, who have a higher likelihood of developing "heart disease, Type 2 diabetes, metabolic syndrome and many types of cancer" in middle-age [6]. There is mounting data that middle age sedentary behaviour, obesity, diabetes, and hypertension are precursors of earlier onset dementia [7].

As rehabilitation neuropsychologists who evaluate older adults for cognitive and memory disorders, it is dismaying to see the growing incidence of metabolic and cardiovascular disease associated with obesity and sedentary behaviours. Many of the dementias may be due to poor

lifestyle choices, and not primary medical illnesses or genetics [8]. These lifestyle choices are modifiable. This paper will explore factors and interventions which have shown promise in promoting healthy neurocognitive aging and slowing abnormal neurocognitive aging such as dementia and age-related memory loss [9]. Primary areas covered will include what has been referred to as the "Holy Trinity" of positive behavioural interventions to promote healthy aging: Exercise, Sleep, and Diet. Ancillary interventions are also reviewed.

2. Exercise

Multiple organizations have developed guidelines for activity levels to reach therapeutic benefits from exercise. Numerous studies have documented the increase in neurocognitive performance from exercise interventions. The aetiology is not clear, but such factors as increases in brain derived neurotrophic factor, glial cell neurotrophic factor, lowering of insulin resistance, increases in cardiovascular and cerebrovascular blood flow, and increases in all neurotransmitter production and balance are among hypotheses studied. Cognitively, exercise is felt to increase working memory and executive functioning. Normalized neuroelectrical functioning of the brain (suggestive of better cognitive functioning) has been found with both intense and incidental everyday exercise. Psychologically, exercise has been associated with reductions in depression and anxiety as well as concomitant increases in self-esteem and quality of life. These psychological factors can lead to a greater sense of optimism and efficacy, prompting participation in other health promotion behaviours.

2.1 Exercise Guidelines

In their Physical Activity Guidelines for Americans 2nd Edition [10], recently revised guidelines from the U.S. Department of Health and Human Services Center for Disease Control and Prevention retained the long-standing recommended requirements for cardiovascular exercise to receive therapeutic benefits for physical, psychological and neurocognitive health [11]. Globally, these recommendations were issued by the World Health Organization [12]. For adults under age 65 who do not have contraindicated medical illnesses, 150 minutes of moderate cardiovascular exercise per week is recommended. "Moderate" exercise is defined by the American Heart Association [13] as exercising at 50 to 70% of one's maximum heart rate for age. Alternatively, the Harvard T.H. Chan School of Public Health [14] grades exercise by exertion as measured in Metabolic Equivalent of Tasks or METS, with "Moderate" exercise in the 3 to 6 METS range. The recommended exercise time can be reduced to 75 minutes per week if one exercises at a "Vigorous "level", defined as an exercise heart rate greater than 75-85% of one's age-adjusted maximum, or exercise exertion greater than 6 METS. Muscle strengthening activities involving the major muscle groups are recommended two or more days per week. For Older Adults age 65 and greater, the time recommendations double to 300 minutes of moderate cardiovascular exercise per week, or 150 minutes of vigorous cardiovascular exercise, or some combination of the two levels of intensity. A new PAG-2 recommendation for the older group is for balance training, which is needed to counteract problems with gait and balance dysfunction with typical aging. Balance training also can help prevent or reduce fall risk associated with serious health consequences such as hip or vertebral fractures or geriatric traumatic brain injury. Further, more sophisticated forms of balance training such as tai chi are felt to improve executive functioning by exercising the

prefrontal lobe cortex motor fields. One major change to the CDC PAG-2 recommendations is that the prior recommendation for at least a 10 consecutive minute period of moderate to vigorous physical activity (termed "bouted MVPA") has been dropped, as newer evidence shows positive effects for reduced metabolic syndrome with bouted and nonbouted but intense physical activity [15]. Because removal of the minimum 10 minute sustained duration guideline "encourages Americans to move more frequently throughout the day" [16], it has been well received as "a potential game-changer for boosting population-level physical activity...[as] people are now given permission to move in ways they prefer and that fit into their complex lives" [17].

2.2 Benefits of Exercise

In addition to reducing the incidence of chronic illness which can impair healthy aging, positive changes from exercising to a therapeutic level include increase in brain volume, brain-derived neurotrophic factor (BDNF), insulin sensitivity, cardiac health, heart rate variability, and healthy sleep and declines in blood pressure, LDL lipids, cancer risk, and risk of premature death [18-20] Psychological benefits of cardiovascular exercise to recommended levels include reduction in depression and anxiety and enhancement of self-esteem, self-efficacy, and quality of life [21-24]. Neurocognitive benefits have been identified for working memory, attentional processes and executive functioning [23-27]. Most promising, studies indicate that therapeutic exercise may decrease risk, onset time and/or effects of dementia [9, 28, 29] and may normalize brain EEG against age-related declines in resting alpha peak frequency [30].

2.3 Exercise Options

The type of cardiovascular exercise depends on one's initial fitness level and any comorbid medical illnesses. Weight-bearing exercises such as walking, jogging, running, or exercising on a treadmill or elliptical are highly recommended [10]. In persons with ambulatory, balance or joint problems, options include nonweight-bearing exercise such as a rowing machine, Tai chi or lower impact exercises such as water aerobics [28]. If medically tolerated, the newer approach of High Intensity Interval Training (HIIT) optimizes time of work out, and may have benefits greater than steady-state exercise [31, 32]. It is postulated that HIIT affects memory abilities mediated by the hippocampus and executive abilities mediated by the frontal cortex. However, research is only currently being conducted to investigate the role of HIIT on Brain Derived Neurotrophic Factor (BDNF) and other mechanisms to support this hypothesis [20]. Incidental physical activity in older adults, such as yard work, housework and caretaking for a spouse or family member has been found to increase cognitive performance and normalize resting state EEG when performed at a sufficiently high level of intensity. High levels of incidental physical activity are positively associated with cognition and EEG activity in aging [33].

3. Sleep

3.1 Sleep and Aging

Normal aging adversely affects several parameters of sleep. Changes in sleep efficiency, total sleep time, and reductions in percentage of both Rapid Eye Movement (REM) sleep and slow wave sleep occurs [34]. These changes are usually associated with decrements in cognitive performance,

such as attention, working memory, declarative memory, accuracy of performance, and reaction time [35]. Our modern lifestyles are in many ways incongruent with our evolutionary heritage for sleep. While body regulation may function optimally on a 24-hour circadian rhythm where we rise and sleep in line with the sun, technological advances and environmental changes have significantly disrupted our sleep-wake cycles and impinged on restful and restorative sleep. Many electrical devices (lights, TV's, computers, Smart Phones) give off significant amounts of blue wavelength light in the electromagnetic spectrum. When the brain perceives light, either natural or man-made, the suprachiasmatic nucleus will not signal the pineal gland to release melatonin, needed to begin the sleep cycle. This effect is likely worse in older adults given their already reduced ability to produce and release melatonin. Fortunately, there are many behavioural interventions which can address sleep dysfunction in older adults beyond the exercise guidelines outlined above.

3.2 Benefits of Sleep Hygiene

Normal aging adversely effects sleep onset and ability to reach deeper levels of restorative sleep. The primary behavioural intervention for primary insomnia is Cognitive Behavioural Therapy for Insomnia (CBT-I). CBT-I postulates that poor sleep involves cognitive distortions about sleep quality as well as poor sleep hygiene. Establishing and maintaining Sleep Hygiene includes implementation of simple behaviour changes such as: developing consistent times to go to bed and wake up, even on weekends; avoidance of daytime napping of greater than 15-20 minutes; restricted use of the bed for sleep and sex; and leaving the bedroom if sleep onset has not occurred within 20 minutes. Supportive approaches include reduction in late evening caffeine intake, alcohol consumption and stimulating exercise activities. The bedroom sleep environment can be modified to be more comfortable by using "black-out" shades or blinds; keeping the bedroom dark and cooled to about 65°F; wearing blue light blocking glasses several hours before bed; and minimizing electronics that emit blue light. Finally, sleep onset and maintenance can be enhanced by practicing relaxation approaches such as mindfulness meditation, listening to relaxation tapes, and self-hypnosis.

Of importance to the aging population is emerging research suggesting a strong role of deep restorative sleep and the prevention of Alzheimer's Disease. A primary mechanism implicated is the newly-discovered glymphatic system in the brain that essentially washes the brain during deeper stages of sleep [36]. It is thought that this process removes amyloid-beta plaque by-products characteristically seen in Alzheimer's. Implementation of sleep hygiene protocols may help offset reductions in deep slow wave delta sleep typically seen with aging, hopefully supporting this glymphatic clearance pathway.

4. Diet and Nutrition

While modern technology has adversely affected sleep quality, the modern diet has adversely affected basic health parameters, leading to increases in obesity and chronic illness. Such illnesses in the US and worldwide include diabetes, heart disease, stroke and some types of cancer [37]. As discussed, these illnesses can lead to abnormal brain aging, neurocognitive dysfunction, and poorer mental health. Among dietary approaches, adherence to the simple metabolic equation is

a basic way to reduce the incidence of obesity: maintain an energy balance in which the number of calories consumed equals the number of calories used by the body for activities of daily living.

4.1 Benefits of Dietary Modification

While almost any dietary approach can be better than the modern commercial "fast food" diet, many commercial dietary systems focus on weight loss and not necessarily maintenance of a heart or brain healthy diet. A version of the Mediterranean diet, the "MIND" diet (Mediterranean – Dietary Approaches to stop hypertension) has been researched rigorously and found to reduce the incidence of abnormal brain neuropathology [38]. The MIND Diet has also been found to reduce the incidence of Dementia, and conversion of Mild Cognitive Impairment to Dementia [39, 40]. The risk for Alzheimer's disease was reduced when the MIND Diet was paired with exercise. Longevity was increased by an average of four years or longer in persons who developed Alzheimer's while maintaining a healthy diet. On the other hand, a recent brain MRI study of older persons who survived mainly on a fast food commercial diet showed accelerated brain shrinkage, especially in the memory important hippocampus [41].

4.2 Dietary Guidelines and Caveats for Older Adults

As each person's dietary needs are individual due to a number of biological, social and medical factors, consultation with a registered dietitian or nutritionist is recommended to develop the best dietary plan. With this caveat in mind, research evidence generally associates positive health outcomes and reduced risk of heart disease, stroke and cancer with diets primarily made up of unprocessed foods such as fruits, vegetables, complex carbohydrates and healthy poly- and mono-unsaturated fats from sources such as nuts, seeds, olive oil, and avocados. While the Ketogenic diet (a high fat, low carbohydrate, modest protein diet) has shown efficacy in epilepsy and migraine, it has not been sufficiently researched in dementia or brain trauma and intuitively, it may not be beneficial. Similarly, Intermittent Fasting is a promising area of dietary research that involves time-restricted eating or fasting over a period of hours within a day, or days within a week. Two popular approaches are the 16/8 and 5:2 methods. In mice, where most of the research has been conducted, restricted eating improved neural connections in the hippocampus, which is instrumental in memory. Intermittent fasting may thus be a promising intervention for middle age persons adopting patterns to improve current health and minimize future risk of age-related neurocognitive decline. However, it should be noted that the Alzheimer's Association does not recommend fasting for older persons, who may already be eating a diet altered by age-related changes in senses of smell and taste, and may become physically vulnerable due to improper nutrition. Similar concerns were noted for intermittent fasting for older persons with dementia and Parkinson's disease [39].

5. Neurofeedback and Other Brain Training

One biological measure of the functional activity of the human brain is the electroencephalogram (EEG). In normal aging, the EEG reflects changes which are felt to parallel decrements in intellectual abilities and cognitive processing in older adults. There is some controversy about whether these measured processes are normal variants of aging, or actually

reflect a neuropathological process. Nevertheless, common findings on the EEG in older adults are characterized by "slowing of the alpha rhythm, increase in slow waves, and focal disturbance" [42]. These electrical measures are felt to reflect slowing of cognitive processing, decrements in working memory and executive functioning, and inter-hemispheric and intra-hemispheric communication difficulties. Neurofeedback and Brain Training approaches discussed below are utilized to modify EEG patterns correlated with adverse neurocognitive effects of aging.

5.1 Background on Neurofeedback

Traditionally, the EEG is a tool of clinical neurology which uses the International 10-20 topographic system to noninvasively measure the amplitude of four broad frequency bands over specific cortical brain sites, primarily to view significant pathology such as epilepsy, tumours, brain injury or metabolic disturbance. The EEG proceeded modern neuroimaging techniques such as CT, MRI and PET scans by decades. Since the 1960s, biological processes in the body have been monitored, including heart rate, respiration, muscle tension, skin conductance, skin temperature, and more recently the EEG. A representation of these processes can be fed back to the person being monitored in the form of auditory and/or visual stimuli. In biofeedback (BFB) interventions, in addition to monitoring such stimuli, the individual is taught through an operant conditioning paradigm to increase or decrease the amount of a signal reflecting the biological process, with the goal of improving health and/or optimizing performance. BFB approaches have been well documented for basic physiological processes such as headache from excessive muscle tension or cold hands from peripheral vascular constriction. Neurofeedback (NFB) involves monitoring and modifying brainwave activity as detected on the EEG.

5.2 Benefits of Neurofeedback

Neurofeedback interventions are currently being applied to altering the usual neuroelectrophysiologic changes seen in normal aging, as well as abnormal processes such as dementia. While initially NFB focused on one brain EEG site, it has since expanded to be used with multiple sites, and in both static and dynamic domains. Doing so, NFB treatment can help reverse the slowing of the alpha rhythm by focusing on one to four brain sites [43, 44]. It also can normalize neuroelectrical activity at multiple sites simultaneously, thereby increasing efficient activation and communication throughout the cerebral cortex. This latter technique focuses training on four to nineteen brain sites and is called Live Z Score Training [44].

There is promising research suggesting neurofeedback can improve cognition in the elderly [45]. Neurofeedback to enhance cognitive functioning and to counter the effects of aging has been referred to as ‘‘brain brightening’’ [46, 47]. Other research suggests a positive correlation between excessive slow brainwave (theta) activity and mild cognitive impairment or dementia [48]. Two studies found neurofeedback training that involved the inhibition of theta activity in participants aged 60-85 led to improved cognitive performances on neuropsychological tests such as verbal comprehension, attention, orienting, recognition memory, and executive functions [49, 50]. Anecdotal evidence suggests that NFB paired with aerobic exercise may further reduce neurocognitive decline in the elderly.

While most traditional physiologic biofeedback interventions have not shown promise for reducing age-related cognitive decline, passive Infrared hemoencephalography (pIR HEG)

biofeedback using sensors positioned proximally over the forehead and distal from the frontal lobes measure temperature as an indirect measurement of frontal blood flow. Increasing blood flow and frontal temperature is thought to reflect increased activation of the frontal cortices. In normal ageing, there are cellular atrophy and microvascular changes felt to diminish higher level cortical functions, such as executive abilities and working memory [51]. pIR HEG is an non-invasive , easy intervention which may help with these critical functions in normal aging or pathological conditions [52].

6. Transcranial Neuromodulation Interventions

Neuromodulation therapies allow focused delivery of modifying agents (e.g. electrical, optical or chemical signals) to targeted areas of the nervous system in order to improve neural function. Neuromodulation differs from traditional neurofeedback by directing stimuli into the brain, rather than passively monitoring the brain's signals, and changing their frequency and/or intensity by operant conditioning and self-regulation strategies.

6.1 Transcranial Photobiomodulation

A promising area of clinical research in the prevention of neurocognitive decline is the use transcranial photobiomodulation (aka Low Level Light Therapy or LLLT), which involves the non-invasive application of near infrared (NIR) light (typically 810 nm) to a person's head. NIR, at a specific pulse wavelength, has been shown to penetrate the scalp and skull to the cerebral cortex. One wears a headset with four groups of light emitting diodes that focus on hubs of the important Default Mode Network, a network of brain electrical activity for awareness, cognition and consciousness. Photobiomodulation is thought to enhance mitochondrial function (and therefore ATP production) and reduce neuronal apoptosis in human and animal cells [53]. The postulated mechanism of action for photobiomodulation is increased cerebral oxygenation, which serves to activate neuronal repair and growth while reducing inflammation [54].

6.2 Benefits of Transcranial Photobiomodulation

There is increasing evidence that transcranial photobiomodulation may be effective in the treatment of neurodegenerative disorders such as Alzheimer's and Parkinson's diseases [54-57]. In addition there is evidence that the application of NIR to the cerebral cortex can improve mood and cognitive functions in healthy subjects, including enhancing reaction time, attention, memory, and executive functions, all areas that normally decline with advancing age [58-61].

6.3 Other Transcranial Neuromodulation Interventions

Chemical neuromodulation involves the use of traditional psychopharmacology, which is beyond the scope of this article. Older neuromodulation approaches include electrical and electromagnetic stimulation of the brain through wearable sensors. While this technology has applications for mood disorders such as anxiety and depression, it has not shown efficacy in age-related neurocognitive decline nor in the dementias.

7. Other Approaches to Support Healthy Aging

7.1 Sauna Benefits

The use of saunas for improving overall health has been an area of recent scientific investigation. There is increasing empirical evidence that regular sauna use of at least two to three times per week for 20 minutes at a temperature of 174 F in conventional saunas (and likely less with infrared saunas) may be associated with reduced overall mortality [62], blood pressure [63], and risk of stroke [64], cardiac disease [62], respiratory diseases [65], and Alzheimer's disease or other causes of dementia [66]. The mechanisms are not completely understood but appear to be related to a reduction in inflammation, blood pressure, insulin resistance, and arterial stiffness in the brain and body [67]. In addition, it is assumed that regular sauna use has effects on hormones such as growth hormone and insulin-like growth factor-1 (IGF-1) which promote muscle and body repair and increase neurogenesis. Heat stress from sauna use also increases BDNF when combined with exercise. BDNF increases the growth of new brain cells, the survival of existing neurons, and neuroplasticity, which may lead to increasing cognitive reserve. There is also evidence that exposure to heat via saunas can have positive effects on psychological health [68]. This is likely due to increased release and storage of norepinephrine, which can improve cognitive functions such as attention, and prolactin found to be associated with myelination.

7.2 Supplements

A number of supplements have been studied in hopes to improve health and reduce the effects of aging. The most conservative view regarding supplementation is that supplements are needed only if one is deficient in a certain vitamin or mineral needed for optimal metabolism, and these cannot be obtained through a healthy diet. However, other healthcare providers aggressively recommend supplements. A cautious middle position is that supplements with an adequate evidence base may be useful when used as part of a comprehensive, well monitored healthcare plan. Among the most researched supplements are various precursors to the coenzyme nicotinamide adenine dinucleotide (NAD+), including components of vitamin B3 such as niacinamide and nicotinamide riboside. NAD+ has been found to decline with age [69], and associated with various age-related diseases [70]. NAD+ has been found to activate anti-aging enzymes such as sirtuins, enzymes that help repair damaged DNA (e.g., PARPs), improve age-related decline in the circadian rhythm [71], and improve mitochondrial health [72]. In addition, healthy NAD+ levels may protect the brain against axonal degeneration [73], and improve cognitive function or slow the progression of Alzheimer's disease in animal models [74]. Levels of Vitamins D and B-12 are routinely measured in regular physical examinations, given their contribution to physical and cognitive health.

The purported health benefits of red wine are thought to be primarily the result of the polyphenol antioxidant resveratrol that is found in the vines and skin of red grapes. Resveratrol, also available as a supplement, has been found to improve mitochondrial function in animal models [75, 76], and may play a role in preventing Alzheimer's disease [77]. However, the research is contradictory. The recommendation of alcohol use is also controversial. In a recent editorial in the British Medical Journal, Welch notes memory problems from hippocampal atrophy with

alcohol use in a dose dependent manner and no health benefit for light drinkers over abstainers [78].

8. Conclusion

Normal aging does not inevitably portend acquisition of chronic health problems and faltering mental acuity. As we have attempted to show, avoidance of certain unhealthy habits and behaviors and adoption of healthy habit and behavioural alternatives can foster good mental and neurocognitive health throughout the lifespan. Resistance to societal pressure, aggressive commercial marketing and immediate gratification in favour of healthier alternatives does require some self-discipline or self-regulation, but ultimately yields health rewards. As discussed, mounting research evidence supports identification of Exercise, Sleep and Diet/Nutrition as core health modifiers for healthy living at any age. Following specific cardiovascular exercise guidelines, implementing sleep hygiene strategies to improve restorative sleep, and maintaining a brain and heart healthy diet can forestall or minimize the normal physical and mental decline often associated with aging. Adjunct activities and complementary interventions such as neurofeedback, neuromodulation, sauna and supplements are also being investigated and show some promise for healthy physical and neurocognitive aging. Ironically, despite impressive and expensive advances in neuroimaging and genetics and their contribution to the neuroscientific study of Alzheimer's and dementia, research supports behavioural and basic health strategies as most efficacious in a neuroprotective capacity. Behavioural and complementary interventions, coupled with a positive attitude and a supportive community, may help optimize physical and neurocognitive abilities throughout the lifespan.

Disclaimer

The information in this article is intended for educational purposes only. One should consult with one's physician or appropriate healthcare provider before initiating any therapies addressed in this article.

Author Contributions

RLC and AAC conceptualized the paper. RLC, CF and AAC wrote the paper.

Competing Interests

The authors have declared that no competing interests exist.

References

1. World's older population grows dramatically [Internet]. National Institutes of Health (NIH). 2016 [cited 2018 November 29]. Available from: https://www.nih.gov/news-events/news-releases/worlds-older-population-grows-dramatically
2. Sahoo K, Sahoo B, Choudhry A, Sofi N, Kumar, Bhadoria, A. Childhood obesity: Causes and consequences. J Fam Med Primary Care. 2015; 4: 187-192.

3. Long C. When physical education is cut, who picks up the slack? NEA TODAY. [cited 2019 February 27]. Available from: http://neatoday.org/2017/03/28/cuts-to-physical-education/
4. Stitt C, Kunkel D. Food advertising during children's television programming on broadcast and cable channels. Health Commun. 2008; 23:573-584.
5. Robinson T, Banda J, Hale L, Lu A, Fleming-Milici F, Calvert S, Wartella, E. Screen media exposure and obesity in children and adolescents. Pediatrics. 2017; 140: S97-S101.
6. Obesity Facts [Internet]. Centers for Disease Control and Prevention: CDC Healthy Schools. [Cited February 27, 2019]. Available from: https://www.cdc.gov/healthyschools/obesity/facts.htm
7. Chuang Y, An Y, Bilgei M, Wong D, Troncoso J, O'Brien R, Breitner J, Ferruci L, Resnick S, Thambisetty M. Midlife adiposity predicts earlier onset of Alzheimer's dementia, neuropathology and presymptomatic cerebral amyloid accumulation. Mol Psych. 2016; 21: 910-915.
8. Nine lifestyle changes may reduce risk of dementia [Internet]. nhs.uk. 2017 [cited 2018 November 29]. Available from: https://www.nhs.uk/news/neurology/nine-lifestyle-changes-may-reduce-risk-of-dementia/
9. Baumgart M, Synder H, Carrillo M, Fazio S, Kim H, Johns H. Summary of the evidence on modifiable risk factors for cognitive decline and dementia: A population-based perspective. Alzheimer's Dementia. 2015; 11: 718-726.
10. Physical activity guidelines for Americans (2nd ed.) 2018. Washington, DC: U.S. Department of Health and Human Services. [Internet]. Available from: https://health.gov/paguidelines/second-edition/]
11. Piercy K, Troiano R, Ballard R, Carlson S, Fulton J, Galuska D, et al. The physical activity guidelines for Americans. JAMA. 2018; 320: 2020.
12. Physical Activity [Internet]. World Health Organization. [Cited 2018 November 29]. Available from: http://www.who.int/dietphysicalactivity/pa/en/
13. Know your target heart rates for exercise, losing weight and health. [Internet]. American Heart Association. [Cited 2019 March 01]. Available from: https://www.heart.org/en/healthy-living/fitness/fitness-basics/target-heart-rates
14. Measuring physical activity. [Internet]. Harvard T. H. Chan School of Public Health. [Cited 2019 March 01]. Available from: https://www.hsph.harvard.edu/nutritionsource/mets-activity-table/
15. Robson J, Janssen I. Intensity of bouted and sporadic physical activity and the metabolic syndrome in adults. PeerJ. 2015; 3: e1437.
16. Top 10 things to know about the second edition of the physical activity guidelines for Americans. [Internet]. Office of Disease Prevention and Health Promotion. [Cited 2019 March 01]. Available from: https://health.gov/paguidelines/second-edition/10things/
17. Segar M, Gibala M. Active voice: From prescription pad to movement menu – Why updated physical activity guidelines for Americans (PAG) are a game-changer. [Internet]. Sports Medicine Bulletin: American College of Sports Medicine. [Cited 2019 February 27]. Available from: http:// http://www.multibriefs.com/briefs/acsm/active022619.htm
18. Colcombe SJ, Erickson KI, Scalf PE, Kim JS, Prakash R, McAuley E, et al. Aerobic exercise training increases brain volume in aging humans. J Gerontol A Biol Sci Med Sci. 2006; 61: 1166-1170.

19. Warburton D, Nicol C, Bredin S. Health benefits of physical activity: The evidence. CMAJ. 2006; 174: 801-809.
20. Jimenez-Maldonado A, Renteria I, Garcia-Suarez PC, Moncada-Jimenez J, Freire-Royes LF. The impact of high-intensity interval training on brain derived neurotrophic factor in brain: A mini-review. Front Neurosci. 2018; 12: 839.
21. Blumenthal J, Babyak M, Moore K, Craighead W, Herman S, Khatri P, et al. Effects of Exercise Training on Older Patients With Major Depression. Arch Intern Med. 1999; 159: 2349-2356.
22. Loprinzi P, Davis R. Bouted and non-bouted moderate-to-vigorous physical activity with health-related quality of life. Prev Med Reps. 2016; 3: 46-48.
23. Mandolesi L, Polverino A, Montuori S, Foti F, Ferraioli G, Sorrentino P, et al. Effects of physical exercise on cognitive functioning and wellbeing: Biological and psychological benefits. Frontiers in Psych. 2018; 8: 1-11.
24. Executive Summary: Physical activity guidelines for Americans (2nd ed.) 2018. [Cited 2019 March 01]. Washington, DC: U.S. Department of Health and Human Services. [Internet]. Available from: https://health.gov/paguidelines/second-edition/pdf/PAG_ExecutiveSummary.
25. Pargman D. Boomercise. Morgantown: Fitness Information Technology; 2012.
26. Baniqued P, Gallen C, Voss M, Burzynska A, Wong C, Cooke G, et al. Brain network modularity predicts exercise-related executive function gains in older adults. Front Neuroendocrinol. 2018; 9.
27. Kramer A, Hahn S, Cohen N, Banich M, McAuley E, Harrison R, et al. Aging, fitness and neurocognitive function. Nature. 1999; 400: 418.
28. Northey JM, Cheruin N, Pumpa KL, Smee DJ, Rattray B. Exercise interventions for cognitive functions in adults older than 50: A systematic review with meta-analysis. Br J Sports Med. 2018; 52: 154-160.
29. Gallaway P, Miyake H, Buchowski M, Shimada M, Yoshitake Y, Kim A, et al. Physical activity; A viable way to reduce risks of mild cognitive impairment, Alzheimer's diease, and vascular dementia in older adults. Brain Sci. 2017; 7: 1-16.
30. Angelakis E, Stathopoulou S, Frymiare J, Green D, Lubar J, Kounios J. EEG Neurofeedback: A brief overview and an example of peak alpha frequency training for cognitive enhancement in the elderly. Clin Neuropsychol. 2007; 21: 110-129.
31. Gibala M, Heisz J, Nelson A. Interval training for cardiometabolic and brain health. ACSM's Health Fit J. 2018; 22: 30-34.
32. Zimmerman M. 99 ways to add healthy years to your life. AARP Bulletin. 2019: 1016.
33. Sanchez-Lopez J, Silva-Pereyra J, Fernández T, Alatorre-Cruz G, Castro-Chavira S, González-López M, et al. High levels of incidental physical activity are positively associated with cognition and EEG activity in aging. PLOS ONE. 2018; 13: e0191561.
34. Moraes W, Piovezan R, Poyares D, Bittencourt L, Santos-Silva R, Tufik S. Effects of aging on sleep structure throughout adulthood: a population-based study. Sleep Med. 2014; 15: 401-409.
35. Alhola P, Polo-Kantola P. Sleep deprivation: Impact on cognitive performance. Neuropsychiatry Dis Treat. 2007; 3: 553-567.
36. Tarasoff-Conway J, Carare R, Osorio R, Glodzik L, Butler T, Fieremans E, et al. Clearance systems in the brain—implications for Alzheimer disease. Nat Rev Neurol. 2015; 11: 457-470.

37. Adult Obesity Causes & Consequences | Overweight & Obesity | CDC [Internet]. Cdc.gov. [updated 2018; cited 2018 November 29]. Available from: https://www.cdc.gov/obesity/adult/causes.html
38. Rainey-Smith S, Gu Y, Gardener S, Doecke J, Villemagne V, Brown B, et al. Mediterranean diet adherence and rate of cerebral Aβ-amyloid accumulation: Data from the Australian imaging, biomarkers and lifestyle study of ageing. Transl Psychiatry. 2018; 8: 238.
39. Cohen M. Brain food. Neurol Now. 2017; 13: 22-35.
40. McEvoy C. Healthy Eating Habits May Preserve Cognitive Function and Reduce the Risk of Dementia. Alzheimer's Association International Conference; 16th-20th July 2017; London, England.
41. Jacka F, Cherbuin N, Anstey K, Sachdev P, Butterworth P. Western diet is associated with a smaller hippocampus: A longitudinal investigation. BMC Med. 2015; 13: 215.
42. Koyama K, Hirasawa H, Okubo Y, Karasawa A. Quantitative EEG correlates of normal aging in the elderly. Clin EEG Neurosc. 1997; 28: 160-165.
43. Soutar, R. & Longo, R.E. Doing Neurofeedback: An Introduction. San Rafael: ISNR Research Foundation; 2001.
44. Collura T, Frederick J. Handbook of clinical QEEG and neurotherapy. New York: London Routledge; 2017.
45. Gruzelier J. EEG-neurofeedback for optimising performance. I: A review of cognitive and affective outcome in healthy participants. Neurosci Biobehav Rev. 2014; 44: 124-141.
46. Hammond D. What is neurofeedback: An update. J Neurotherapy. 2011; 15: 305-336.
47. Budzynski, T.H. Brain brightening: Can neurofeedback improve cognitive process? Biofeedback. 1996; 24: 14-17.
48. Babiloni C, Squitti R, Del Percio C, Cassetta E, Ventriglia M, Ferreri F, et al. Free copper and resting temporal EEG rhythms correlate across healthy, mild cognitive impairment, and Alzheimer's disease subjects. Clin Neurophysiol. 2007; 118: 1244-1260.
49. Becerra J, Fernández T, Roca-Stappung M, Díaz-Comas L, Galán L, Bosch J, et al. Neurofeedback in healthy elderly human subjects with electroencephalographic risk for cognitive disorder. J Alzheimers Dis. 2012; 28: 357-367.
50. Wang J, Hsieh S. Neurofeedback training improves attention and working memory performance. Clin Neurophysiol. 2013; 124: 2406-2420.
51. Calso C, Besnard J. Normal aging of frontal lobe functions. Geriatr Psychol Neuropsychiatr Vieil. 2016; 14: 77-85.
52. Pérez-Álvarez F, Timoneda-Gallart C, Serra-Sala M. Clinical usefulness of hemoencephalography beyond the neurofeedback. Neuropsychiatr Dis Treat. 2016: 12: 1173-1180.
53. Lu Y, Wang R, Dong Y, Tucker D, Zhao N, Ahmed M, et al. Low-level laser therapy for beta amyloid toxicity in rat hippocampus. Neurobiol Aging. 2017; 49: 165-182.
54. Hamblin M. Shining light on the head: Photobiomodulation for brain disorders. BBA Clinical. 2016; 6: 113-124.
55. Lapchak P. Transcranial near-infrared laser therapy applied to promote clinical recovery in acute and chronic neurodegenerative diseases. Expert Rev Med Devices. 2012; 9: 71-83.

56. Purushothuman S, Johnstone D, Nandasena C, Mitrofanis J, Stone J. Photobiomodulation with near infrared light mitigates Alzheimer's disease-related pathology in cerebral cortex – evidence from two transgenic mouse models. Alzheimer's Res Ther. 2014; 6: 2.
57. Johnstone D, Moro C, Stone J, Benabid A, Mitrofanis J. Turning on lights to stop neurodegeneration: The potential of near infrared light therapy in Alzheimer's and Parkinson's disease. Fronti Neurosci. 2016; 9.
58. Blanco N, Maddox W, Gonzalez-Lima F. Improving executive function using transcranial infrared laser stimulation. J Neuropsychol. 2015; 11: 14-25.
59. Disner S, Beevers C, Gonzalez-Lima F. Transcranial laser stimulation as neuroenhancement for attention bias modification in adults with elevated depression symptoms. Brain Stimul. 2016; 9: 780-787.
60. Grover F, Weston J, Weston M. Acute effects of near infrared light therapy on brain state in healthy subjects as quantified by qEEG measures. Photomed Laser Surg. 2017; 35: 136-141.
61. Gonzalez-Lima F, Barrett D. Augmentation of cognitive brain functions with transcranial lasers. Fronti Systs Neurosci. 2014; 8.
62. Laukkanen T, Khan H, Zaccardi F, Laukkanen J. Association between sauna bathing and fatal cardiovascular and all-cause mortality events. JAMA Intern Med. 2015; 175: 542.
63. Zaccardi F, Laukkanen T, Willeit P, Kunutsor S, Kauhanen J, Laukkanen J. Sauna bathing and incident hypertension: A prospective cohort study. Am J Hypertens. 2017; 30: 1120-1125.
64. Kunutsor S, Khan H, Zaccardi F, Laukkanen T, Willeit P, Laukkanen J. Sauna bathing reduces the risk of stroke in Finnish men and women. Neurol. 2018; 90: e1937-e1944.
65. Kunutsor S, Laukkanen T, Laukkanen J. Sauna bathing reduces the risk of respiratory diseases: a long-term prospective cohort study. Eur J Epidemiol. 2017; 32: 1107-1111.
66. Laukkanen T, Kauhanen J, Laukkanen J. Sauna bathing is inversely associated with dementia and Alzheimer's disease in middle-aged Finnish men. Age Ageing. 2017; 46: 245-249.
67. Laukkanen J, Laukkanen T. Sauna bathing and systemic inflammation. Eur J Epidemiol. 2017; 33: 351-353.
68. Janssen C, Lowry C, Mehl M, Allen J, Kelly K, Gartner D, et al. Whole-body hyperthermia for the treatment of major depressive disorder. JAMA Psychiatry. 2016; 73: 789.
69. Massudi H, Grant R, Braidy N, Guest J, Farnsworth B, Guillemin G. Age-associated changes in oxidative stress and NAD+ metabolism in human tissue. PLoS ONE. 2012; 7: e42357.
70. Houtkooper R, Auwerx J. Exploring the therapeutic space around NAD+. J Cell Biol. 2012; 199: 205-209.
71. Nakahata Y, Sahar S, Astarita G, Kaluzova M, Sassone-Corsi P. Circadian control of the NAD+ salvage pathway by CLOCK-SIRT1. Science. 2009; 324: 654-657.
72. Imai S, Guarente L. NAD+ and sirtuins in aging and disease. Trends Cell Biol. 2014; 24: 464-471.
73. Sasaki Y, Araki T, Milbrandt J. Stimulation of nicotinamide adenine dinucleotide biosynthetic pathways delays axonal degeneration after axotomy. J Neurosci. 2006; 26: 8484-8491.
74. Gong B, Pan Y, Vempati P, Zhao W, Knable L, Ho L, et al. Nicotinamide riboside restores cognition through an upregulation of proliferator-activated receptor-γ coactivator 1α regulated β-secretase 1 degradation and mitochondrial gene expression in Alzheimer's mouse models. Neurobiol Aging. 2013; 34: 1581-1588.

75. Csiszar A, Labinskyy N, Pinto J, Ballabh P, Zhang H, Losonczy G, et al. Resveratrol induces mitochondrial biogenesis in endothelial cells. Am J Physiol Heart Circ Physiol. 2009; 297: H13-H20.
76. Kim S, Joe Y, Zheng M, Kim H, Yu J, Cho G, et al. Resveratrol induces hepatic mitochondrial biogenesis through the sequential activation of nitric oxide and carbon monoxide production. Antioxid Redox Signal. 2014; 20: 2589-2605.
77. Porquet D, Casadesús G, Bayod S, Vicente A, Canudas A, Vilaplana J, et al. Dietary resveratrol prevents Alzheimer's markers and increases life span in SAMP8. AGE. 2012; 35: 1851-1865.
78. Welch K. Alcohol consumption and brain health. BMJ. 2017; 357: j2645.