

Review Article

Neurohealth Manifestations Rendered by Physical Exercise and Diet

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ABSTRACT

The outcome of combining physical exercise, whether endurance-type or resistance-type, with dietary selection, or even the exercise regime by itself has been shown repeatedly to endower numerous beneficial manifestations that stretch over multiple domains that include immune defense systems and anti-disease pathological effects, chronic metabolic disorder, cognitive-affective states and alimentary canal microbiota. The combination of exercise with selective, not merely restrictive, diets mobilizes a multiplicity of cellular adaptive responses and signaling pathways, reduced pro-inflammatory and increased anti-inflammatory cytokines, more effective cognitive performance in emotionally-charged situations and general health, well-being and quality-of-life improvements.

Keywords: Physical exercise; Cognition; Performance; Elderly; Metabolism; Immune function; Health benefits

Movement and bodily activities that sustain and augment physical capacity and vigor entails the individual's commitment to regular and frequent physical exercise/exercise schedules. Exercise may be defined as a series of planned and structured physical activities that fulfill the intention of developing and advancing several domains health, physical fitness and functional sufficiency (Morris and Schoo, 2004), independent of the individual's age and circumstance (Archer, 2014; Archer and Garcia, 2015). It has been described as any and all physical activity that generates force through muscular force that disrupts another muscular force (McArdle et al., 1978). Muscular exertion through physical activity offers manifest benefits foe cerebral integrity and neurocognition (Bediz et al., 2016; Marks et al., 2010; Segalowitz, 2016), in addition to enrichment pertaining to general measures of bodily structure and function, improved quality-of-life and physical endurance and strength (Deschamps et al., 2010; Marks et al., 2009), not least for benefits of elderly and ageing populations whether under institutionalized or home-dwelling conditions (Archer, 2011). In multivariate regressions analysis that included body size and physical activity parameters, human total energy expenditure exceeded that of four primate species, chimpanzees and bonobos, gorillas and orangutans, by approximately 400, 635 and 820 kcal/day, respectively, readily accommodating the cost of humans' greater brain size and reproductive output. A great proportion of the increase in total energy expenditure was attributable to the humans' greater basal metabolic rate (kcal/day), indicating increased organ and tissue metabolic activity (Pontzer et al., 2016). Physical exercise has been depicted upon an underpinning of distinguished through type, intensity, frequency, combination, and duration, with either endurance or resistance, or ingredients of each, as the end-point of training and not least the self-regulation of exercise parameters (Abasi et al., 2016; Foulds et al., 2014; Mougios, 2010). Resistance exercise develops the capacity to oppose the force of muscular contraction with hydraulic or elastic resistance, a specific variant of strength training that employs hydraulic/elastic tension or torsion to generate this resistance (Peterson et al., 2010). On the other hand, endurance exercise training promotes the capacity to exert oneself over long periods of activity evolutions utilizing different variations and combinations of movement (Chen et al., 2016). Nevertheless, the relationship between muscle strength and physical, exertional performance as predictors of clinical markers, such as mortality, hospitalization, care-giver burden and disability in the oldest old ought not to be overlooked (Legrand et al., 2014). Physical exercise and other lifestyle interventional strategies are considered increasingly both more attractive in view of the questions raised concerning the efficacy and cost-benefit dilemmas arising from the use/misuse of cognition-enhancing drugs (Albertson et al., 2016), and in view of individuals', sometimes latent, propensities to endeavor to modulate their own health status (Archer and Garcia, 2014; Garcia and Archer, 2014). For example, even moderate levels of exercise improved markedly cognitive performance on the Stroop task in addition to reducing snack food consumption (Lowe et al., 2016).

The present method offers a review of health-oriented physical exercises with results obtained from both clinical, preclinical and laboratory studies. There is an accumulating bulk of plausible evidence emphasizing the premise that the additive effects of exercise and restricted and 'tailor-made' diet interventional procedures has produced noticeably beneficial outcomes in the normal elderly and those afflicted by neurodegenerative conditions (Meeusen, 2014): In a large study to assess a multi-domain approach to prevent cognitive decline in at-risk elderly people from the general population, Ngandu et al (2015) observed an improved or maintained adequate neurocognitive functioning in at-risk elderly people. Brain-rest-of-central nervous system (CNS)-movement propensity links affect reciprocal determinant influences upon each other. CNS-mediated physical mobility deficitsmay present a relatively new and increasingly prevalent condition among elderly and older elderly adult populations globally. Interventions targeting this group may have the potential to improve mobility and cognition and prevent disability. Studies carried out using laboratory animal models and human subjects have displayed robust beneficial effects of regular physical exercise and intermittent energy restriction/fasting on cognitive function and mood, particularly in the contexts of aging and associated neurodegenerative disorders (Mattson, 2015), as well as from other types of brain injury (Archer, 2012). The concurrent administrations of exercise interventions, i.e. aerobic and non-aerobic regimes, and/or aerobic-only exercise interventions have induced regularly positive effects on cognitive performance, whereas, nevertheless, these outcomes tended to be absent in the case of non-aerobic exercise interventions with both high frequency and low frequency interventions affecting cognitive performance (Archer, 2013). Fjeldsoe et al. (2016) employed a message-texting intervention, from a population-level, applying a behavioral telephone-coaching program, message-frequency, timing, and content of the messages that was based on participant preferences, ascertained during two tailoring telephone calls, with primary outcomes of body weight, waist circumference, physical activity (walking, moderate, and vigorous sessions/week), and dietary behaviors (fruit and vegetable serves/day, cups of sweetened drinks per day, takeaway meals (and other 'junkfoods') per week; fat, fibre and total indices from the Fat and Fiber Behavior Questionnaire) were assessed via self-report before (baseline measures) and after (6 months) in older middle-aged adults (50-60 years). They obtained significant intervention effects with weight changes and increseases in moderate physical activity measures. Varmi et al., 2016 have shown that prevention and intervention provided improvements within differents areas of treatment, such as (i) pharmacology and diet; (ii) exercise; (iii) electrical stimulation; (iv) sensory stimulation/deprivation; and (v) a combined category of multimodal interventions.

Choice of lifestyle exerts an essential influence upon health, well-being and quality-of-life with a sedentary existence, as opposed to exercise compliance, and overconsumption and poor diet, as opposed to dietary selection and restriction (Archer and Garcia, 2015), as very real risk factors for condition of ill-health, such as diabetes type II. For example, the burden of non-alcoholic fatty liver disease is increasing worldwide (de la Monte and Tong, 2013), and the efficacy of exercise-based lifestyle interventions on liver-specific end-points in populations with non-alcoholic liver disease and similar underlying metabolic disorders, such as obesity, type-2 diabetes, or metabolic syndrome conditions are emerging with increasing preponderance. In a meta-analysis of data from 28 clinical trials, Orci et al., 2016 found that physical activity by itself independent of dietary alterations was linked to a marked decreases in intra-hepatic lipid content as well as reductions in alanine aminotransferase and aspartate aminotransferase. Applying meta-regression, they observed that individuals hampered by increased body mass index shown to be more likely to benefit from the intervention. It appears that the physical activity regime reduced intrahepatic lipid content and markers of hepatocellular injury in patients presenting non-alcoholic liver disease with these reductions correlated with individuals' baseline body mass index. In a study of whether or not physical exercise could effect a prevention of diabetes, Hicks et al., 2016 observed the effects of voluntary wheel-running schedules upon the progression of diabetes-like symptoms and open field and light-dark box behaviors among C57BL/6J mice that were fed a high-fat diet. These mice were placed into either running-wheel cages or cages without a running-wheel, administered either regular chow or a high-fat diet, and their body mass, food consumption, glucose tolerance, insulin and c-peptide levels were all registered. The mice were exposed also to the open field activity and light-dark box tests for spontaneous behavior anxiety-like behaviors. Running-wheel behavior attenuated partially the observed obesity and hyperinsulinemia development linked with high-fat diet consumption in these mice, but did not affect either the measured levels of glucose tolerance or c-peptide. Wheel-running behavior elevated markedly anxiety-like and decreased explorative-like behaviors in the open field and light-dark box tests whereas the high-fat diet consumption induced lesser increases in anxiety. This pattern of results implies that voluntary wheel-running can ameliorate some, but not all, of the physiological problems related to high-fat diets possibly through modifications of anxiety-like behaviors independent of dietary properties. In a rodent model of insulin resistance, Yu et al., 2016 assessed the influence of exercise training upon triglyceride deposition and the expression of musclin and glucose transporter 4 (GLUT4) in male Sprague-Dawley rats (8 weeks old, weight 160 ± 10 g) that were fed a high-fat diet (40% calories from fat) and separated into a high-fat control group and a swimming intervention group and the control group rats fed standard food as normal control. It was observed that the eight-week swimming exercise intervention decreased markedly body weight and visceral fat content concurrent to an increased insulin sensitivity index of the rats fed with a high-fat diet, as well as improved serum levels of triglyceride and free fatty acids in addition to muscle triglycerides deposition elevations in high-fat diet rats. The swimming intervention improved dramatically the high-fat induced elevations of musclin and reduced glucose transporter 4 expression the expression of musclin and in the muscles of rats fed a high-fat diet. It seems noteworthy that greater musclin expression is linked with insulin resistance in skeletal muscle with exercise interventions improving lipid metabolism and insulin sensitivity probably through up-regulating glucose transporter 4 and down-regulating musclin.

A condition of low-grade, chronic inflammation arising from a condition of immune dysfunction has been linked to individuals presenting obesity (e.g. Lee et al., 2016). Zhao et al., 2016 set up a procedure that combined physical exercise with administrations of pomegranate extract, to test for anti-obesity, anti-inflammatory and antioxidant effects. They obtained additive effects upon inhibition of high-fat diet-induced body weight increase and improved high-fat diet-induced immune dysfunction that included: (i) attenuation of histomorphologic abnormalities of the spleen, (ii) elevated ratios of the CD4+:CD8+ T cell subpopulations in splenocytes and peripheral blood mononuclear cells, (iii) inhibition of apoptosis in splenocytes and peripheral blood mononuclear cells, (iv) normalization of peritoneal macrophage phenotypes, and (v) restoration of immunomodulating factors present in serum. High-fat diet-induced immune dysfunction was linked to elevated pro-inflammatory cytokine secretion and oxidative stress biomarkers that were blocked effectively by the exercise+pomegranate extract treatment combination. Peripheral mononulear cellular capability for producing cytokines is altered by physical exercise. In order to examine the influence of exercise combined with docosahexaenoic acid dietary supplement upon cytokine produced, induced by liposaccharide-stimulated peripheral mononulear cells, Capo et al., 2016 employed 15 male soccer players who were either treated with docosahexaenoic acid dietary supplement or a similar non-enriched beverage, and blood samples taken before and after acute exercise. The exercise schedule increased drastically IL6, IL8, VEGF, INFγ, TNFα, IL1α, IL1β, MCP1 and EGG production rates induced by liposaccharide-stimulated peripheral mononulear cells, and this effect was attenuated by docosahexaenoic acid dietary supplementation. Diet alters the gut microbiota, which contributes to aspects of metabolic disease during obesity whereas exercise provides metabolic benefits during obesity. It has been shown that high-intensity physical exercise increased the diversity and metabolic capacity of distal gut microbiota during high-fat diet-induced obesity in mice (Denou et al., 2016), through increasing the alpha density and bacteroidetes to firmicutes ratio. Finally, in a study illustrating that diet selection and high-level exercise interact to influence the body's defense force against breast cancer, Theriau et al., 2016 demonstrated that high activity levels increased adipopectin, implicated in the resistance to cancer cells, and abolished the effects of high-fat diet on proliferating MCF7 cells; thus voluntary high intensity running by patients removed the proliferative effects of adipose tissue on breast cancer development.

In concluding, the present account describes several domains in which regular physical exercise, optimally combined with selective diets, may be expected to contribute to improved health and performance. Central issues pertaining to these benefits included: the tailoring of type-of-exercise to individual requirements, choice of physical condition and fitness, particular needs for specific condition of health/ill-health, and prevention and intervention.

REFERENCES

1. Abasi MH, Eslami AA, Rakhshani F and Shiri M (2016) Development and psychometric properties of a self-regulation scale about leisure time physical activity in Iranian male adolescents. Iran J Nurs Midwifery Res. 21(2):183-90. doi: 10.4103/1735-9066.178246.
2. Albertson TE, Chenoweth JA, Colby DK and Sutter ME (2016) The Changing Drug Culture: Use and Misuse of Cognition-Enhancing Drugs. FP Essent. 441:25-9.
3. Archer T (2011) Physical exercise alleviates debilities of normal aging and Alzheimer's disease. Acta Neurol Scand 123, 221-238.
4. Archer T (2012) Influence of physical exercise on traumatic brain injury deficits: Scaffolding effect. Neurotox Res DOI: 10.1007/s12640-011-9297-0.
5. Archer T (2014) Health benefits of physical exercise for children and adolescents. J Novel Physiother 4, 203-206.
6. Archer T and Garcia D (2014) Physical exercise improves academic performance and well-being in children and adolescents. Int J School Cogn Psychol 1, e102.
7. Archer T and Garcia D (2015) Exercise and dietary restriction for promotion of neurohealth benefits. Health 7, 136-152. DOI: 10.4236/health.2015.71016.
8. Bediz CS, Oniz A, Guducu C, Ural Demirci E, Ogut H et al. (2016) Acute Supramaximal Exercise Increases the Brain Oxygenation in Relation to Cognitive Workload. Front Hum Neurosci. 10:174. doi: 10.3389/fnhum.2016.00174.
9. Capó X, Martorell M, Sureda A, Batle JM, Tur JA et al. (2016) Docosahexaenoic diet supplementation, exercise and temperature affect cytokine production by lipopolysaccharide-stimulated mononuclear cells. J Physiol Biochem. 2016 May 2.
10. Chen MC, Chen KM, Chang CL, Chang YH, Cheng YY et al. (2016) Elastic Band Exercises Improved Activities of Daily Living and Functional Fitness of Wheelchair-bound Older Adults with Cognitive Impairment: A Cluster Randomized Controlled Trial. Am J Phys Med Rehabil. 2016 May 4.
11. de la Monte SM and Tong M (2013) Insulin resistance and metabolic failure underlie Alzheimer's disease. In: Farooqui T, Farooqui AA (Eds.), Metabolic Syndrome and Neurological Disorders, John Wiley & Sons, New York, pp. 1-30. DOI: 10.1002/9781118395318.ch1.
12. Denou E, Marcinko K, Surette MG, Steinberg GR and Schertzer JD (2016) High intensity exercise training increases the diversity and metabolic capacity of the mouse distal gut microbiota during diet-induced obesity. Am J Physiol Endocrinol Metab:ajpendo.00537.2015. doi: 10.1152/ajpendo.00537.2015.
13. Deschamps A, Diolez P and Thiaudieri (2010) Effects of exercise programs to prevent decline in health related quality of life in highly deconditioned institutionalized elderly persons: a randomized controlled trial. Arch Intern Med 170, 162-169.
14. Fjeldsoe BS, Goode AD, Phongsavan P, Bauman A, Maher G et al. (2016) Evaluating the Maintenance of Lifestyle Changes in a Randomized Controlled Trial of the 'Get Healthy, Stay Healthy' Program. JMIR Mhealth Uhealth. 2016 May 10; 4(2):e42.
15. Foulds HJ, Bredin SS, Charlesworth SA, Ivey AC and Warburton DE (2014) Exercise volume and intensity: a dose response relationship with health benefits. Eur J App Physiol 114, 1563-1571.
16. Garcia D and Archer T (2014) Positive affect and age as predictors of exercise compliance. PeerJ, 2, e694. DOI: 10.7717/peerj.694.
17. Hicks JA, Hatzidis A, Arruda NL, Gelineau RR, De Pina Monteiro I et al. (2016) Voluntary wheel-running attenuates insulin and weight gain and affects anxiety-like behaviors in C57BL6/J mice exposed to a high-fat diet. Behav Brain Res. pii: S0166-4328(16)30267-4. doi: 10.1016/j.bbr.2016.04.051.

18. Lee MJ, Yang RZ, Karastergiou K, Smith SR, Chang JR et al. (2016) Low expression of the glucocorticoid-induced leucine zipper may contribute to adipose inflammation and altered adipokine production in human obesity. J Lipid Res. pii: jlr.M067728.

19. Legrand D, Vaes B, Mathei C, Adriaensen W, Van Pottelbergh G et al. (2014) Muscle strength and physical performance as predictors of mortality, hospitalization and disability in the oldest old. J Am Geriatr Soc 62, 230-236. DOI: 10.1111/jgs.12653.

20. Lowe CJ, Kolev D and Hall PA (2016) An exploration of exercise-induced cognitive enhancement and transfer effects to dietary self-control. Brain Cogn. pii: S0278-2626(16)30037-9. doi: 10.1016/j.bandc.2016.04.008.

21. Marks BL, Katz L and Smith JK (2009) Brain and the aging mind: buffing the baby boomers body and brain. Phys Sports Med 37, 119-125.

22. Marks BL, Katz L, Styner M and Smith JK (2010) Aerobic fitness and obesity: relationship to cerebral white matter integrity in the brain of active and sedentary older adults. Br J Sports Med 45, 1208-1215.

23. Mattson MP (2015) Lifelong brain health is a lifelong challenge: from evolutionary principles to empirical evidence. Ageing Res Rev. 2015 Mar;20:37-45. doi: 10.1016/j.arr.2014.12.011.

24. McArdle WD, Katch FI and Katch VI (1978) Appendix C. In: Lupash E (Ed) Essentials of exercise physiology. Lippincott Williams and Wilkens, Baltimore, p. 723.

25. Meeusen R (2014) Exercise, nutrition and the brain. Sports Med 44, 4756. DOI: 10.1007/s40279-014-0150-5.

26. Morris M and Schoo A (2004) Optimizing exercise and physical activity in older adults. Butterworth Heinemann, Edinburgh.

27. Mougios V (2010) Exercise metabolism. In: Bahrke MS (Ed) Exercise biochemistry. Human Kinetics, Champaign, p. 122.

28. Ngandu T, Lehtisalo J, Solomon A, Levälahti E, Ahtiluoto S et al. (2015) A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. Lancet. 385(9984):2255-63. doi: 10.1016/S0140-6736(15)60461-5.

29. Peterson MD, Rhea MR, Sen A and Gordon PM (2010) Resistance exercise for muscular strength in older adults: a meta-analysis. Ageing Res Rev. 9(3):226-37. doi: 10.1016/j.arr.2010.03.004.

30. Orci LA, Gariani K, Oldani G, Delaune V, Morel P et al. (2016) Exercise-based Interventions for Non-alcoholic Fatty Liver Disease: a Meta-analysis and Meta-regression. Clin Gastroenterol Hepatol. 2016 May 4. pii: S1542-3565(16)30149-5. doi: 10.1016/j.cgh.2016.04.036.

31. Pontzer H, Brown MH, Raichlen DA, Dunsworth H, Hare B et al.(2016) Metabolic acceleration and the evolution of human brain size and life history. Nature. doi: 10.1038/nature17654.

32. Segalowitz SJ (2016) Exercise and Pediatric Brain Development: A Call to Action. Pediatr Exerc Sci. 28(2):217-25. doi: 10.1123/pes.2016-0028.

33. Theriau CF, Shpilberg Y, Riddell MC and Connor MK (2016) Voluntary Physical Activity Abolishes the Proliferative Tumor Growth Microenvironment Created by Adipose Tissue in Animals Fed a High Fat Diet. J Appl Physiol (1985). jap.00862.2015. doi: 10.1152/japplphysiol.00862.2015.

34. Varma VR, Hausdorff JM, Studenski SA, Rosano C, Camicioli R et al. (2016) Aging, the Central Nervous System, and Mobility in Older Adults: Interventions. J Gerontol A Biol Sci Med Sci. 2016 May 6. pii: glw080.

35. Yu J, Zheng J, Liu XF, Feng ZL, Zhang XP et al. (2016) Exercise improved lipid metabolism and insulin sensitivity in rats fed a high-fat diet by regulating glucose transporter 4 (GLUT4) and musclin expression. Braz J Med Biol Res. 2016;49(5):e5129. doi: 10.1590/1414-431X20165129.

36. Zhao F, Pang W, Zhang Z, Zhao J, Wang X et al. (2016) Pomegranate extract and exercise provide additive benefits on improvement of immune function by inhibiting inflammation and oxidative stress in high-fat-diet-induced obesity rats. J Nutr Biochem. 2016 Feb 28;32:20-28. doi: 10.1016/j.jnutbio.2016.02.003.

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