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Physical Exercise and its Impact on Psychology

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Abstract

Physical exercise impacts upon a plethora of psychological domains: cognition, emotion, development, motor, behavioral, clinical, lifespan and ageing and biological. In the present account, two aspects of exercise intervention are considered, cognitive and emotional with particular reference to conditions of abnormal behavior and brain disorder. Despite developmental disadvantages, it appears the regular and sustained exercise endowers lasting and resilient benefits for health and well-being.

Keywords: Exercise; Cognition; Performance; Emotion; Expression; Intervention

Introduction

The multi-dimensional impact of physical exercise upon psychology and behavioural science is linked to the manifest health-beneficial expressions of physical exercise over individuals' life-cycles, whether normal or in ill-health, may be encapsulated within several domains of welfare: (i) exercise and academic and other cognitive performances, (ii) exercise and the developmental trajectory, (iii) exercise for the alleviation of affective disorders, and (iv) the epigenetic manifestations of physical exercise. Surprisingly, the effects of exercise may be determined relatively quickly: just eight weeks of pre-season training on body composition, physical fitness, anaerobic capacity, and isokinetic strength in collegiate taekwondo athletes in endurance gave improvements on all these parameters, as assessed by relative peak power and anaerobic capacity and angular velocity [1]. Psychological well-being, cognitive, emotional, motor, behavioral, clinical, recuperative, epigenetic and health domains all make considerable impact upon individuals' propensity for and compliance with regular exercise and physical activity and *vice versa* throughout the lifespan development [2-16]. Accordingly, physical exercise is viewed as a "scaffolding" construct that buttresses against illness and damage incurred under conditions, such as traumatic brain injury, clinical depression, developmental disorders or neurodegenerative diseases and aging, by shaping conditions for construction, damage control and reconstruction. It furnishes ongoing processes that are maintained across the lifespan through the applications and development of complementary, alternative biomarkers and neural networks for the attainment of selected functions and performances [17,18]. For example, [19], using data from the ageing population of the "Betula" study (Umeå, Sweden) have shown that (i) higher levels of physical activity score were related to greater connectivity in the posterior default-mode network, (ii) higher levels of physical activity score were related to larger gray matter volume of the posterior cingulate cortex, and (iii) higher levels of physical activity score were related to higher perfusion rate within the posterior cingulate cortex.

Studies derived from several cognitive domains underline the necessity of physical exercise, over a sedentary existence, in ensuring adequate functioning [20]. As a step contributing to improved cognitive performance, running induces neurogenesis in the dentate gyrus of the hippocampus [21,22]. In studies of C_{57}/B_{16} mice, with or without access to running-wheels [23], observed a shift in new neuron networks and three-fold increments in neurogenesis in the dorsal, but not the ventral, dentate gyrus, whereas afferent-traced cell labeling doubled in number. Regional analysis indicated that running differentially affected specific inputs such that contextual, spatial and temporal information encoding by increasing adult hippocampal neurogenesis and by reorganization of new neuron circuitry was facilitated. In humans, hippocampal involvement is implicated in 'face-name' relational memory and visual episodic memory, which provided the most powerful relationships in the strong positive association between physical activity and episodic memory performance [24]. In studies of the detrimental effects of maternal deprivation in rodents for later inhibitory avoidance conditioning [25,26] it has been shown that physical exercise prevented short-term and long-term deficits in aversive and recognition memory performance and attenuated oxidative stress damage induced by the the deprivation schedule [27]. In chronically-stressed mice, the co-administration of physical exercise with dietary supplements induced marked elevations in the number of double cortin-positive immature neurons in the dentate gyrus, the sectional area of the dentate gyrus and hippocampal CA1 region, in addition to an increased hippocampal brain-derived neurotropic factor messenger ribonucleic acid (mRNA) and serum vascular endothelial growth factor concentrations, thereby bestowing multiple benefits [28,29]. In older adults (mean age 81.6 years) with postural problems ('falling-down' disabilities), executive functioning has been shown to present a marker of resiliency in several noncognitive, affective domains predicting reductions in symptoms of depression and maintenance of instrumental activities of daily living; improved executive functioning was predicted by physical activity gait speed, physical exercise and improved maintenance of instrumental activities of daily living during follow-up [30]. There is evidence supporting the associations among physical activity/exercise, cognitive vitality, neural functioning, and the moderation of these associations by genetic factors whereby the former preserves and augments cognitive vitality and its related neural circuitry in older adults, with the preponderance of benefits seen for tasks/functions that are supported by the prefrontal cortex and the hippocampus [31].

Well-trained, regularly exercising individual exhibit lesser physiological and behavioral responses to stressful provocations

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and more effective recovery from provocation than sedentary individuals [32-34]. In families identified by depressed parents, adolescent mental health problems were found to be commonplace; nevertheless, a large portion (20%) of the adolescents expressed sustained good mental health with frequent exercise linked to parent positive expressed emotion, co-parent support, good-quality social relationships, and self-efficacy [35]. In a comparison of highly trained and sedentary young adult men, randomly assigned to either exercise on a treadmill at moderate intensity (60-70% VO2max) for 30 min, or to perform 30 min of a "placebo" exercise [36], obtained a significantly reduced cortisol response to the Montreal Imaging Stress Task (employing functional magnetic resonance imaging), which was inversely related to the previous exercise-induced α-amylase and cortisol fluctuations in the treadmill-exercise group. They observed also higher bilateral hippocampus activity and lower prefrontal cortex activity in this group. Higher aerobic fitness, highly trained men, was associated with lower cortisol responses. The acute stress-buffering effect of exercise hinges upon those negative feedback mechanisms originating from the hippocampus and prefrontal cortex that direct the regulation of the hypothalamus-pituitary-adrenal (HPA) axis. In this context it was shown that treadmill running exercise yielded beneficial effects by ameliorating the anxiety effects and the dysregulation of HPA axis induced by early life exposure to di-(2-ethylhexyl)-phthalate in adolescent female rats [37]. The notion of Mental and Physical Training envisages dependent measures of aerobic fitness (as assessed by maximal rate of oxygen consumed) concurrent with reductions in the observed symptoms of depression and anxiety among troubled individuals [38,39]. Mental and Physical Training (two sessions / week over eight weeks) produced these improvements whereas similar improvements were not observed in a group of recently homeless women who did not participate in MAP Training [40]. Neuropsychiatric conditions present frequent co-morbid status with chronic systemic diseases exemplified by the high incidences of depression; anxiety and cognitive impairment complicate cardiovascular and metabolic disorders such as hypertension and diabetes mellitus [41]. Thus, the positive effects of active lifestyle that incorporated exercise and activity, upon non-psychotic mental disorders in patients presenting chronic systemic diseases was described [42]. Finally, exercise combined with thiamine supplementation improved spatial memory performance and brain-derived neurotropic factor and acetylcholine in the hippocampus of the stressed Wistar rats [43].

In conclusion, the alleviating effect of physical exercise over multiple symptom domains continues to furnish convincing evidence for this noninvasive, non-pharmacological intervention. For example, in a laboratory model of attention-deficit/hyperactive disorder presented by spontaneously-hypertensive rats, it was shown that 5, 10, or 21 days of access to a running wheel, but not 2 days, significantly reduced levels of the norepinephrine transporter in medial prefrontal cortex and demonstrated a robust habituation to a non-reinforced visual stimulus that was indistinguishable from normo-active rats whereas pretreatment with propranolol, β-adrenergic/noradrenergic receptor blocker, abolished the exercise-induced reduction in orienting behavior [44], thereby establishing the impact of exercise on both behavior and biomarker.

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