

## Neuroscience of Exercise and Virtual Reality Applications

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Physical exercise has an important role in general health and well-being. In the last 30 years, the scientific community began research in the field of neuroscience and exercise [1]. Up to date, around 1,753 studies (average 58/year) related to this subject were published [2]. The neuroscience of exercise addresses the effects of exercise on the brain in different populations (older adults, athletes, patients with neurological disorders and children). Although this subject is a relatively new research area, much evidence has already shown the benefits of exercise on mental health [3]. Some of the neurobiological mechanisms of exercise are related to neurogenesis, angiogenesis and synaptogenesis, among others [4], which are hypothesized as being beneficial for the treatment of Parkinson's disease, Alzheimer's disease, Major Depression, and cognitive impairment [3-5].

Recently, new strategies added to physical exercise have been used in diverse rehabilitation fields, such as robotic, biofeedback, cortical stimulation and virtual reality, among others [6-9]. Specifically related to virtual reality and exercise in rehabilitation settings, it is important to highlight the benefits, feasibility, safety, and availability of some commercial devices. These equipments are inexpensive, easily used by healthy professionals and can be applied in several fields of rehabilitation [10,11]. The main benefits associated to physical exercise coupled to virtual reality are the improvement of physical performance and cognitive functions of patients with neurological disorders and older adults. These effects can be explained by neuroplasticity.

During exercise coupled to virtual reality, the individual is immersed in a virtual environment, which causes the "presence". Immersion is the amount of sensorial flow of information that stimulates many sensorial systems and, consequently, simulates a virtual environment. This leads to the production of physiological responses and feelings related to this environment. Therefore, the product of immersion is known as presence (sensation of staying in a given location) [12]. These phenomena influence brain behavior and can alter motor and cognitive responses. You et al [13] demonstrated a cortical reorganization in stroke survivors after a rehabilitation program of exercise coupled to virtual reality. Extraordinarily, the ipsilateral regions of the injured brain became more active during isometric knee extension. These results were associated with motor improvement. In this context, Maillot et al [14] demonstrated improvement of cognitive function and motor performance of healthy older adults after physical exercise training with exergames (exercise and active video games). Thus, this kind of exercise training appears to be an effective intervention from brain to body.

Immersion in a virtual environment requires the activation of important brain regions related to movement and cognition. This activation is critical for navigation abilities. Maguire et al [15] showed that the prefrontal cortex, caudate nucleus, hippocampus, and parietal cortex increased their activation during navigation activities. These results were associated to decision making, planning, velocity of displacement, episodic memory, and accuracy during navigation. Therefore, it is possible that motor stimulation in conjunction with virtual navigation can produce higher power clinical results. This speculation is based on two hypotheses: 1. Physical exercise stimulates the release of peripheral trophic factors, which can cross the blood brain barrier; and 2. Virtual reality can stimulate cognitive brain regions, increasing the release of central trophic factors. Both stimulations by dual task could improve brain functioning and clinical responses [16].

Although virtual reality and exercise applications in neuroscience require future investigations, studies have been important in demonstrating clinical benefits for different populations. The use of this kind of intervention is encouraged in neuroscience fields, although caution is needed since adverse effects related to excessive exposure to virtual reality is not yet well understood.

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