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Less Exercise, More Effects: Useful Assessment of Voluntary Resistance Wheel Running on Brain Plasticity

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Abstract

Exercise is effective of enhancing both cardiovascular, musculoskeletal capacity and brain function if done abundantly. However, the optimal exercise condition for such effects remains controversial. Recently, it is still certain whether voluntary resistance wheel running (VRWR) as strength model of exercise shown to enhance aerobic capacity as effectively as wheel running (WR). We have demonstrated that the VRWR has beneficial effects on our brawn and brain, not only with regard to muscular adaptations, but also with respect to brain function enhancing neurogenesis and spatial memory related to hippocampal brain-derived neurotrophic factor (BDNF). Moreover, a high-throughput DNA microarray approach to gain deep insight into underlying molecular mechanisms for VRWR-induced improvement of hippocampal function. Also, we found inflammatory cytokines and chemokines that might help to counteract neuronal dysfunction and vulnerability. Taken together, these results suggest providing new evidence that VRWR, which is more efficient for improving physical capacity. Furthermore, even with short distance, is beneficial for enhancing brain functions associated with hippocampal plasticity.

Keywords: *voluntary resistance wheel running(VRWR), hip+pocampus, brain-derived neurotrophic factor (BDNF), high intensity exercise, DNA microarray*

Physical activity is effective for enhancing both aerobic capacity as well as brain function. A number of studies have shown that exercise-induced improvements in various markers of cardiovascular and skeletal muscle adaptation [1-3]. In addition to, exercise increases central nervous system such as hippocampal neurogenesis [4,5], which is associated with hippocampus-dependent spatial learning & memory functions [6,7]. This evidence suggests that exercise may mediate the potentiation of synaptic transmission and plasticity. Although previous studies have indicated that central and peripheral changes with exercise, the optimal exercise condition for generating beneficial effects remains controversial.

Recently, high-intensity interval training (HIT) describes physical training has a lot of attention that is characterized, intermittent bursts of vigorous activity, interspersed by periods of rest or relaxation. HIT has been shown to affect aerobic capacity, mitochondrial fatty acid oxidation, and cardiovascular risk as effectively as endurance training (ET) [8-10]. In particular, HIT promotes neurotrophic factors comparable to those induced by ET in rat brain [11]. These findings suggests that HIT can serve as an effective alternate to traditional endurance training, producing similar or even greater changes in a range of physiological, performance and health-related markers. However, it has yet to be investigated whether the effect of low-volume HIT on the cognitive functions and its related underlying mechanisms.

Here, the choice of the HIT was based on our earlier findings which possibility of voluntary resistance wheel running (VRWR) to improve the brain functions. Our previous studies have already shown that although VRWR, which increased high energy expenditure with load but did not increase running distance (half

of control), not only replicates the effects of WR on brain-derived neurotrophic factor (BDNF) signaling, but also induces hippocampal adaptations such as neurogenesis in rats [12,13]. Additionally, providing an inventory of newly changed gene expression and identifying alterations in a number of transcriptional pathways in VRWR rat hippocampi [14]. Especially, it is reasonable to assume that BDNF is a key protein supporting the growth, development and survival of neurons, and physical activity increases hippocampal BDNF MRNA and protein [15,16] which in turn promotes hippocampal-dependent cognitive function and neurogenesis [17,18].

RWR allows for a given load on a running wheel and it is a useful exercise model to increase work levels as energy expenditure without physical and psychological stressors. With RWR exercise, enhanced activities of oxidative enzyme citrate synthase together with fast-twitch plantarismuscle hypertrophy are elicited, probably due to the relative high intensity and short duration of intermittent exercise [19-21]. In all, intermittent exercise of high-intensity such as VRWR cause improvement of muscle adaptations and aerobic capacity that could be considered to improve the brain functions simultaneously. Thus, this allows us to postulate that, HIT is similar with RWR, intermittent exercise and produces shorter distances but higher work levels, as "efficiency exercise" it plays a beneficial role in hippocampal functions.

The results confirm and extend our recent findings that VRWR, despite its lower exercise volume and time could have beneficial exercise effects comparable to those of long endurance training running on hippocampal plasticity. Future studies to uncover the involvement of parameters might elucidate the improvement of VRWR-induced hippocampal function. Moreover, it might be a new knowledge that VRWR increases the role of health promotion in preventing and/or treating organ system disorders.

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