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Tyrosine improves cognitive performance and reduces blood pressure in cadets after one week of a combat training course

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ABSTRACT: The effects of the amino acid tyrosine on cognitive task performance were studied on a group of 21 cadets during a demanding military combat training course. In addition, the effects on mood, blood pressure and the norepinephrine metabolite MHPG were determined. Ten subjects received five daily doses of a protein-rich drink containing 2 g tyrosine, and 11 subjects received a carbohydrate rich drink with the same amount of calories (255 kcal). Assessments were made both immediately prior to the combat course and on the 6th day of the course. The group supplied with the tyrosine-rich drink performed better on a memory and a tracking task than the group supplied with the carbohydrate-rich drink. In addition, the supplementation of tyrosine decreased systolic blood pressure. No effects on mood were found. These findings suggest that supplementation with tyrosine may, under operational circumstances characterized by psychosocial and physical stress, reduce the effects of stress and fatigue on cognitive task performance. © 1999 Elsevier Science Inc.

KEY WORDS: Tyrosine, Cognitive performance, Stress, Blood pressure, Mood, Combat course.

INTRODUCTION

Psychosocial and physical stress are known to increase the release of both peripheral and central (brain) norepinephrine (NE) [16,29]. Peripheral and central release of catecholamines are controlled by two separate systems, because peripherally released catecholamines cannot pass the blood— brain barrier. In the frontal cortex, the transmission of noradrenergic neurons is increased by stressful events [16,21]. Noradrenergic projections from the locus coeruleus (LC), which show an increased electrical activity during stress, provide a main innervation to the frontal cortex [1,31]. The activity of noradrenergic neurons in the LC plays an important role in attention processes, alertness, motor activity and the regulation of emotional processes [28]. In animal studies, stress-induced depletion of brain NE was followed by reduced explorative and motor behavior and by behavioral depression [22,41]. Also in humans central NE has been found to be important in maintaining attention. A clonidine-induced inhibition of NE release resulted in an increase in the number of lapses of attention in healthy males, which was reversed by the antagonist idazoxan [34].

With respect to dopamine (DA), a variety of tasks, including active avoidance, passive avoidance and the radial-arm maze, have been used in experimental animals to show the involvement of DA systems in learning and memory. Systemic DA receptor blockade impaired learning in different tasks suggesting the role of DA blockade in producing learning deficits [6,7,24]. Neurotoxic depletion of catecholamines (CA) in the prefrontal cortex of young adult monkeys produced impairment of spatial memory that was reversed by treatment with the DA agonists L-dopa and apomorphine [12]. With respect to humans, some investigators found an increased incidence of dementia in patients with Parkinson's (PD) disease, a syndrome characterized by atrophy and degeneration of DA neurons [18,42]. The existence of a deficit in visuospatial working memory in PD also indicates the involvement of DA in intellectual functioning [10]. However, in animal studies, where the concentration of NE and DA was measured after stress induction, no changes in the concentration DA was found [41]. Therefore, considerably more severe stress seems to be required to alter DA levels in the brain than NE levels. The release of DA may be more related to coping behaviors than to the uncontrollability of the stressor, which appears to be the crucial determinant of the NE response [22].

The large neutral amino acid L-tyrosine, which is the precursor of NE and DA, has been found to enhance NE synthesis [23] and may thus prevent stress-induced NE depletion in the animal brain. In mice, brain tyrosine was found to reach its maximum concentration 1 h after oral ingestion and returned to baseline level after 4 h [39]. In addition, in rats receiving a tyrosine-rich diet, neither NE depletion nor behavioral impairment was found after stress induction [11,22]. Similar results have been found in humans. Young men who were exposed to cold and hypoxia exhibited fewer stress symptoms, such as headache, tension and fatigue, and showed fewer psychomotor impairments after being supplemented with 100 mg/kg tyrosine [5]. In a more recent human study,

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