Acute exercise causes changes in cognition

Catecholamines (dopamine, norepinephrine and epinephrine) play important roles in the brain and in the body. In the brain dopamine and norepinephrine, also known as noradrenaline, act as neurotransmitters. In the body, norepinephrine and epinephrine, also known as adrenaline, act as hormones, which are particularly active during exercise, regulating the cardiorespiratory system. Thus, during exercise, there is demand from the body for increased concentrations of catecholamines. In fact, even before exercise begins, the hypothalamus initiates activity in the brainstem, which initiates the synthesis and release of the catecholamines. Moreover, when we start to exercise, we increase our respiratory and cardiac rates, and our blood pressure rises. Neural receptors on the vagus nerve, which runs from the abdomen through the chest, neck and head, detect this activity as well as the increase in circulating catecholamines. This information is fedback to a part of the brainstem called the the nucleus tractus solitarii (NTS). In turn, the NTS initiates activation of another part of the brainstem, called the locus coeruleus. This is the main region of the brain responsible for producing norepinephrine and distributing it to other parts of the brain, including those involved in cognition. Moreover, norepinephrine also stimulates the synthesis and release of dopamine from yet another part of the brainstem, the ventral tegmental area (VTA). The VTA serves many areas of the brain involved in cognition. Thus we have increased neurotransmitters in the brain regions vital for cognition.

When exercise is comparatively short (less than 20 mins) and of moderate intensity, the increase in catecholamines induces improved cognitive performance in a variety of tasks. At this moment in time, strong evidence of improved cognition is limited to improvements in speed of undertaking the cognitive tasks. However, this is probably because most of the tasks used in research have been tasks in which performance is measured by speed of processing. Some research with tasks, where performance is measured more by accuracy, has shown improvements but more research is required. Following these intensities x durations, brain catecholamines concentrations are optimal.

When moderate intensity exercise is undertaken for long periods of time (greater than 30-40 mins) or when the intensity is increased and exercise becomes heavy, the situation changes. The demand for catecholamines in the body increases, feedback via the vagus nerve to the NTS initiates greater activity in the locus coeruleus and more norepinephrine is released into the brain. This further triggers the releases of dopamine from the VTA, and the amount of catecholamines in the brain becomes excessive. While moderate increases in brain catecholamines produce optimal cognitive performance, excessive concentrations can induce activation of neurons which interfere with performance. This has a negative effect, particularly on tasks which are complex, such as planning, problem solving, abstract thinking and cognitive flexibility. All is not bad however, as tasks which we do automatically show imported performance even when catecholamines concentrations are high. Also some perceptual tasks show improved performance, especially those which are involved in perceiving danger. This appears to be an aid to survival. Perhaps surprisingly, heavy exercise and long-duration, moderate intensity exercise can also aid learning and long-term memory. These types of exercise induce the release of a protein called brain derived

neurotrophic factor (BDNF) in the brain. BDNF plays an important role in learning, particularly in the consolidation of long-term memory. Indeed, the research into the effect of acute exercise on cognition supports the use of daily physical education in schools.

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Publication

Reappraisal of the acute, moderate intensity exercise-catecholamines interaction effect on speed of cognition: role of the vagal/NTS afferent pathway.
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