

Exercise facilitates memory: Implications for helping youngsters learn in school

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Abstract:

Up to this day I still can vividly remember a routine in my elementary school: the daily school-wide morning calisthenics. It started at about 7:45 am in the school courtyard. Our physical education teacher stood on the concrete stage where our principal would give her talk at school assemblies. All children and teachers would follow the teacher's lead to do the eight-segment national calisthenics in unison with loud music from loudspeakers affixed on trees around the courtyard. When I visited the school last May, I saw that students still performed the routine faithfully but with a different set of calisthenics program. The principal said, exactly like what my principal would, that the morning exercise could help students learn in classroom by following the “Three-Excellence” doctrine: excellent health, excellent learner, and excellent citizen.

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Article:

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It has been suspected that exercise helps cognitive learning. Physical educators and exercise scientists alike would like to make the statement intuitively that exercise can facilitate students to learn in all subject areas in schools. Coincidentally with the intuition, emerging research

evidence in kinesiology has begun to show that exercise does help improve certain cognitive functions such as reaction time, attention span, or executive functioning (strategies).

Learning is defined as a complex, multi-dimensional process resulting in relatively long-term (or permanent) changes in cognitive functioning and behavior. One crucial determinant of learning is long-term memory. It is long-term memory that Labban and Etnier¹ were targeting in their research on cognitive impact of acute exercise. The purpose of the study was two-fold: (a) to determine the “effects of acute aerobic exercise on long-term memory” and (b) to pinpoint “the influence of exposure timing to the to-be-remembered information relative to the exercise bout”.

Based on an extensive literature review, the researchers positioned their study on a solid theoretical basis. They not only developed their rationale for the study from a comprehensive theoretical articulation, but also used various theories to guide their research decisions on design, grouping, variable selection, treatment spacing, control condition, and experiment protocol. For example, the decision on exercise intensity and duration was based on the relation between cognitive functioning and the degree of dehydration and physiological exhaustion. The detailed attention to theories rendered a design tight enough for improved internal validity and reliability of all measures and realistic enough for reasonable generalizability of the results.

The study used a randomized, controlled design. The participants were college-age undergraduate students ($n = 48$). After health and habitual physical activity behavior screening, they were randomly assigned to one of the three experimental conditions: Exercise-Prior – where the participants first exercised 30 min at a moderate-vigorous intensity, then studied two paragraphs of learning material, rested for 30 min while exposed to a “distractor” – procedure to clear working memory about the materials studied, after the rest they took a standardized recall test to determine how much information from the learning material was stored in the long-term memory. In the Exercise-After condition, the participants rested first for 30 min, then studied the material, followed by 30-min exercise, then took the recall test. Those in the Control condition followed the Exercise-After protocol, except they did not exercise but rested for another 30 min after studying the learning material. The researchers recorded heart rate (HR) and ratings of perceived effort (RPE, self-report) in 5-min intervals to monitor the process to control for impact from unplanned procedural variations.

The data analysis strategy was planned to ensure accuracy of the results. A repeated-measures analysis of variance (ANOVA) was conducted to detect any procedural interference. Only after it was determined that the between-condition HR and RPE changes were not statistically significant ($p < 0.05$ for time \times condition interaction and for condition main effect), did the researcher proceed to the main effect analysis – a one-way ANOVA. In the analysis the experimental condition was the independent variable and the long-term memory test scores were the dependent variable. For a total of possible 22 recall units, the Exercise-Prior group scored an average of 15.50 ± 4.13 units correct, the Exercise-After group 12.19 ± 4.68 , and the Control group 11.13 ± 4.27 (mean \pm SD). The ANOVA revealed statistically significant difference ($p < 0.05$) between the Exercise-Prior and Control with an effect size of Cohen's $d = 1.04$.

The result answers the research questions cleverly. First, it shows that exercise did facilitate long-term memory (effect). Secondly, only exercising prior to learning facilitated the long-term

memory (timing). While the researchers elaborated on possible mechanisms that the results may have implied, I can't help but think about ramifications of the data to the relation of physical activity and academic learning. The result certainly confirms what others have found that exercise does improve cognitive functions. But its significance appears to go beyond that. It is very exciting to know that the timing of exercise seems to be the sole facilitator for the recall outcome. My principal would have been very happy, had she known the finding; after all, scheduling the morning calisthenics prior to the first period might indeed have facilitated learning in her school!

The researchers pointed out some limitations of the study, the gender-imbalance in the sample and the absence of personal fitness in determining the exercise protocol intensity in the experiment. From my learning-centered perspective, which may be biased, these are trivial limitations. Instead, I would add a cognitive capacity screening test to assess the homogeneity of participants' cognitive capacity across the three conditions. The source of confounding to the dependent variable might not come from the participants' physical activity behavior, but from their initial cognitive capacity. It seems that the researchers relied on the randomization to control for cognitive capacity heterogeneity, a possible systematic sampling error. But sometimes systematic error may occur in a randomized sampling process. If the initial long-term memory was tested prior to the experiment to control for possible confound, the finding would be more strong and convincing.

Although the study helps us move one step closer to establishing the contributing connection between physical activity and academic learning, we still need to be cautious about claiming the contribution based on this and similar studies. A primary reason is that academic learning achievement depends on the relevance of the material to be learned. This relevance, however, was not established in this and other similar studies. I hope that future studies will make a concerted effort to use school-learning relevant materials in experiments so as to help establish a solid connection between exercise and its benefit to academic learning.

Reference

1. Labban J, Etnie JL. Effects of acute exercise on long-term memory. *Res Q Exerc Sport* 2011;82:712e21.