

Correlation between Aerobic Fitness/Exercise and Cognition in Adolescents

Abstract

The purpose of this literature review is to explore the correlation between aerobic fitness/exercise and cognition among adolescents. Five different categories were created to categorize the findings of 14 different peer reviewed researches: academic performance, attention, executive functioning, cognitive performance, and grey and white matter volumes. Although many studies showed positive association between aerobic fitness and cognition, the degree of influence varied based on the aspect of cognition being analyzed. Academic performance of adolescents showed enhanced test scores after bouts of aerobic exercise. Similarly, students showed increased attention capacity and cognitive performance after regular aerobic exercise. Executive functioning, and grey and white matter volume demonstrated mixed results, where some aspects were enhanced by aerobic exercises, but other showed little or no association. These findings could provide insights to future research, educational institutions, educators, policymakers, parents, etc. to further focus on aerobic fitness to increase the cognition in adolescents.

Introduction

Adolescence is a critical period of cognition development. There are many factors affecting and influencing cognitive abilities during this phase. One of the factors that has been gaining increased attention, while also being the subject of numerous studies is: aerobic fitness. This factor and its influence is even more impactful in current time period where many adolescents choose sedentary lifestyles with preference of digital devices over physical and aerobic activities.

This literature review categorizes the results of fourteen peer review articles into five different categories to systematically analyze and establish a correlation between aerobic fitness and exercise on cognitive functioning in adolescents.

Methods

To generate the required pool of articles and published research, the Mississippi State University Library's databases were searched using the EBSCOhost platform. The primary search parameters for the purpose of this review were "aerobic*" and "cognit*". The topic was focused on and narrowed down to a specific area by using the parameters "teen*", "youth*" and "adolescent*" as alternatives to one another. Furthermore, for a more concise outcome, the results were limited to only academic journals published from 2012 to 2023. The above parameters generated 211 articles amongst which 84 were exact duplicates and were thus removed, resulting in 127 being left.

To further narrow down the articles, some exclusion criteria were applied. Articles were excluded if they focused on specific genders, and had contents focused on and around physical, mental, and psychological problems. Additionally, articles were also excluded if they were not in English or if the research was not on humans but on rodents.

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After careful evaluation and consideration, 14 articles were used for the purpose of this literature review. Some of the key terms used while including the articles are: aerobic fitness, aerobic exercise, cognition, cognitive capacity, teen, youths, and adolescents.

Results

Among the list of articles generated for the purpose of the literature review, some focused more on one particular area of cognition than others. Similarly, the means of testing cognition varied between each article. Thus, to summarize the results from all 14 articles and fit into the topic of cognition, 5 categories were created: academic achievements, attention, executive functioning, cognitive performance and volume of grey and white matters. The findings from the generated pool of articles fit within the categorization, and will present a clear format in evaluating the correlation between aerobic fitness and cognition among adolescents.

Academic Achievements

Three articles report the direct testing of the correlation between aerobic exercises and academic achievements in school. The academic achievements were measured in terms of standard tests (Stroop Dot, Stroop Color, Stroop Word test) and academic subjects (mathematics, language, etc.).

One of the articles, [1] found no significant improvement in mathematics test scores. However, the same article did find significant differences between AE (Aerobic Exercise Group) and NE (Non-Exercise Group) in the standard test of Stroop Dot and Stroop Color. This means that when compared to the non-exercise group, the group involved in aerobic exercise had better results in standard tests that are used to measure cognitive performance.

It should also be noted that although overall academic outcomes were not significantly impacted, there was an associated increase in scores, of academic subjects, on all tests [5]. Another study, [9], found that cognitive performance among high-school students was related directly to aerobic fitness. The study [9] showed that aerobic fitness had a positive correlation with all indicators of cognitive performance (Stroop Word, Stroop Color, Stroop Color Word, and mathematics), but not with linguistic subjects like Korean.

The results from all three tests are consistent in showing that aerobic fitness increases the cognitive functioning among adolescents. Although acute aerobic exercises may not have significant impact on the overall academic performances of the students, it may increase their test scores of standard tests.

Attention

Among four articles [3, 4, 8, 10] that were considered in evaluating the correlation among aerobic exercise and attentional capacity in adolescents, three [3, 8, 10] found direct positive relations whereas [4] reported having found lack of association between attentional capacity and daily moderate-to-vigorous physical activity.

Results from both [3, 8] suggest that physical fitness may enhance cognition by making the attentional system in adolescents perform at a more advanced and improved level. Furthermore, study [10] shows

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that the amount of time spent in MVPA (moderate to vigorous physical activity) is directly proportional to the adolescents' test performance in attentional capacity.

The results from the associated tests shows that physical fitness, more specifically, aerobic fitness facilitated an improved efficient attentional system in adolescents. It also showed that the more time they spent in MVPA, the greater impact it would have on their attention capacity.

Executive Functioning

Several of the articles in the pool measured executive functioning (rapid visual information processing, spatial working memory, response inhibition, etc) and its correlation with aerobic fitness. Among the four articles, only one [7] reported positive association whereas the other three [6, 12, 14] showed either no association or insignificant association.

Study [7] suggested cardiorespiratory fitness (one form of aerobic fitness) helped improve planning and problem-solving abilities. It also reported finding association between aerobic fitness and cognitive flexibility (the ability to think about multiple concepts simultaneously) among adolescents.

Article [6] reported small improvements in executive functioning in the AEP (Aerobic Exercise Program) group and RAP (Resistance and Aerobic Exercise Program) group. However, these improvements were not considered as significant findings. Similarly, research in the article [14] showed that aerobic exercise does affect executive functioning in adolescents, but only selectively. At the same time, study [12] found no clear correlation between aerobic fitness and core executive functions.

In conclusion, aerobic exercise improves certain types of executive functioning like planning, problem-solving abilities and cognitive flexibility, but shows little to no association with other types like rapid visual information processing, spatial working memory and response inhibition.

Cognitive Performance

All four of the articles [2, 3, 4, 13] reported a positive relation between cognitive performance and regular aerobic fitness/exercise in adolescents.

Study [4] suggested that aerobic fitness when combined with lower adiposity (lower level of fat) may increase cognitive processing speed. Similarly, article [3] suggests that less fit individuals, when exposed to aerobic exercise might be particularly benefited when it comes to cognitive performance. Additionally, articles [2, 13] report evidence suggesting that the long-term aerobic exercises will improve cognitive functions and performance in the younger population, especially those whose brains are still developing.

Regardless of the target group suggested in the individual researches, all four of them showed that aerobic fitness and aerobic exercises does have impact on the cognitive performance among adolescents.

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Grey/White Matter

Grey matter and white matter are crucial parts of our nervous system and our brain. Grey matters are responsible for processing and interpreting information. Similarly, white matter is responsible for transmitting that information to other parts of the nervous system. The volume and function of both these matters are an essential part of determining the cognitive and mental capacity of an individual.

Two of the articles in the discussed pool found both positive and negative correlations between the volume of these matters and aerobic fitness. Research from article [11] shows negative relation between aerobic fitness and grey matter volume in the brain, whereas another study [12] found positive relation between aerobic fitness and white matter volume.

Thus, it shows that higher aerobic fitness is negatively associated with spatial processing [11], but is important for increased transmission of information to other parts of the nervous system [12].

Discussion

Aerobic fitness and/or aerobic exercise were found to be beneficial to the human brain and its cognition in many of the researches. Though some research showed a lesser association between the two in a particular field, other research suggested significant correlations.

In terms of academic performance, aerobic exercises confirmed a boost in standard cognition test scores like the Stroop Dot and Stroop Color tests. It did not show significant changes in overall academic performances in school, but did enhance test scores in subjects like mathematics. This suggests that taking tests after getting some short bouts of aerobic exercises done might boost tests scores as they will help in thinking more clearly, possibly because of the large amount of oxygen intake during the moderate to vigorous aerobic exercises. Although the aerobic exercises did not directly increase the overall academic performances, it did enhance attentional system in adolescents. The longer the student was involved in daily moderate to vigorous physical activity, the more efficient his attentional functionality and system became. This means that being involved in regular aerobic fitness will increase the attention of adolescents in their daily lives.

Furthermore, aerobic fitness showed increase in white matter volume responsible for information transmission within the nervous system. In addition to that, the most consistent findings emerged in terms of cognitive performance where aerobic exercises were proved to enhance cognitive processing speed. Similarly, cardiorespiratory exercises (a form of aerobic exercise) increased the planning and problem-solving abilities as well as cognitive flexibility (the ability to think about multiple concepts simultaneously) in adolescents. This shows that aerobic fitness impacts not only thinking speed, but also thinking process which might prove to be a significant factor in an adolescents' academic and social life as being involved in daily such exercise will improve the way they think and look at problems.

However, not all article showed positive correlations among certain aspects of cognition. One study showed that aerobic fitness might be detrimental to spatial processing. Another showed that aerobic exercise does not have much significant association/correlation with executive functioning like rapid visual information processing, spatial working memory, response inhibition, etc.

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Limitations

There are two primary limitations of this literature review. One limitation is its lack of ability to prove causal relationship. Even though correlation was found between aerobic fitness and many parts of cognition in adolescents, there was limited evidence establishing a definite relationship where one was the cause of the other. The second limitation is the presence of confounding variables like age, sex, body mass index, parental educational level, fat mass, etc. Only some researches took these variables into account, which means that there might be a possibility of a different result if all these other variables were considered.

Academic Use

These findings could serve as a foundation for future research. Keeping in mind the limitations regarding confounding variables, more extensive research with the isolation of the variables might result in new findings. Similarly, more in-depth research could be done in the correlation between aerobic fitness and cognition. Different testing methods could be used to find the relations between cognition and aerobic exercises in regard to the duration of exercise, time between exercise and standard cognitive test, regularity of exercise, prior involvement in such exercise, etc.

Non-Academic Use

Schools and educational institution can use this review as a source of preliminary evidence for future development and modifications in curriculum involving more aerobic exercises in physical education classes. Being able to integrate more aerobic exercises in the curriculum might improve the cognition of students in the school. Moreover, educators can integrate short bouts of physical activity in their teaching strategies to improve processing speed and attention capacity of their students in the classroom. Similarly, parents can use this as reference to improve the declining performance of their child by focusing on physical, especially aerobic fitness, encouraging more parenting strategies revolving around exercises.

Conclusion

In conclusion, there are positive association between aerobic fitness and some domains/aspects of cognition in adolescents. While attention capacity and cognitive performance showed enhancements due to aerobic exercises, it did not improve spatial processing and had no significant impact on executive functioning. Short bouts of aerobic exercises showed increase in test scores, and regular involvement in MVPA (moderate to vigorous physical activity) enhanced attention, cognitive processing speed, planning and problem-solving abilities, and cognitive flexibility. The review found that aerobic exercises and aerobic fitness were more beneficial to younger population when their brain is still developing. These results may offer insights for future research, educational institutions, teachers, policymakers, and parents, encouraging an emphasis on aerobic fitness to enhance cognitive abilities in adolescents.

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