The European Journal of Biomedical and Life Sciences 2023, No 3
ISSN 2310-5674

PREMIER Publishing
ppublishing.org

Section 2. Life Sciences

DOI: 10.29013/EJBLS-23-3-21-27

EFFECTS OF REGULAR EXERCISE ON COGNITION IN CHILDREN

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Cite: *Spahiu, E., Erindi, A. (2023). Effects of Regular Exercise on Cognition in Children. European Journal of Education and Applied Psychology 2023, No 3.* https://doi.org/10.29013/EJBLS-23-3-21-27

Abstract

Regular exercise has been demonstrated to improve children's physical and mental health in a variety of ways. However, there has been little study on the precise influence of exercise on reaction time, especially among children. The purpose of this study is to investigate the potential effect of regular physical activity on intelligence and reaction time in children. The hypothesis was that engaging in regular physical activity would positively affect cognitive abilities and reaction time. A sample of 40 boys, aged 13-15 was recruited for the purpose of the study. Subjects were divided into two groups, 20 active boys who were part of a local team and 20 inactive boys selected from a local school. Participants were subjected to anthropometric measurements effect of abstract is to summarise the available literature on the effects of regular exercise on children's response time. Participants were also subjected to an IQ Test consisting of 30 questions fitted for their age group, to measure their level of intelligence. While to gauge their ability to react in relation to time and space, subjects were subjected to an audio reaction time test (beep test) while exercising on a treadmill. The differences between the IQ test were in favour of those who didn't participate in sports. The BMI had a strong relationship with physical activity. The relationship between IQ test and reaction time was not significant, however, physical activity affected reaction time positively in both groups. The results of the study did not reveal a significant correlation between regular physical activity and intelligence. Furthermore, no significant correlation was found between physical activity and reaction time. Several factor might contribute to these results. Further research is warranted to explore potential indirect effects of physical activity on cognitive abilities, such as improvements in mood, attention, and overall well-being. In conclusion, these findings emphasize the importance of considering multiple factors when examining cognitive abilities in children and highlight the need for further research in this area.

Keywords: *intelligence, reaction time, children, physical activity, IQ test*

Introduction

Physical activity has always been part of the humankind history. Anthropological studies and historical evidence trace back the existence of such practice since the early prehistoric culture, as means of religious, social and cultural expression (US Department of Health and Human Servicesж Kig, A.C., Martin, J.E., 1994).

Nowadays, physical exercise is an absolute need for all people. With the scientific and technological development that came since the industrial revolution as well as due to the technological evolution we are passing by, we are always facing high levels of stress, anxiety, and sedentary level that compromises the health of a major part of populations around the world both in developed and developing countries.

Epidemiological data on different studies show that moderately active persons have a lower risk to have mental disorders than the sedentary ones, showing that the physical exercise exerts benefits in the physical and psychological sphere (Chodzko-Zajko, W.J., Moore, K.A. 1994; Chodzko-Zajko, W.J., 1991) and the physically active individuals probably have better cognitive skills (Elsayed, M., Ismail, A.H., Young, R.J., 1980; Van Boxtel, M.P., Langerak, K., Houx, P.J., Jolles J. 1996).

Despite of this, Heyn et al. (Heyn, P., Abreu, B.C., Ottenbacher, K.J., 2004), in a meta-analysis, have also found a significant increase in the physical and cognitive performance and a better situation in the elderly people's behavior with impairment of cognitive abilities and dementia. Confirming that practicing physical exercises can be an important protector against the cognitive decline and dementia in elderly individuals (Laurin, D., Verreault, R., Lindsay, J., Mac Pherson, K., Rockwood, K., 2001; Tomporowski, P.D., 2003).

The alert state created by the effects of the exercise is based on the Yerkes-Dodson Law (Yerkes, R.M., Dodson, J.D., 1908). Such law shows the existence of a connection between the cognitive performance and physical activity, similar to what happens to the alert level, as it could promote an initial improvement in the performance, followed by a decline after the increased alert above the resting state. So, it seems there is a clear evidence of the "U" invert relationship between cognition and performance.

Increased physical activity was related to cognitive performance for eight measurement categories, and results indicated a beneficial connection for all of these, with the exception of memory (Sibley, B.A , and Etnier, J.L., 2003).

Recent studies confirm what was observed by Levitt and Gutin (Levitt, S., Gutin, B., 1971, Salmela and Ndoye 1986, and Reilly and Smith 1986), when they investigated the cognitive and perceptive-motor performance after 6 minutes of exercise on bicycle at different intensities of theVO2 max. The individuals completed perceptive-motor tasks in the end of each intensity of the exercise; in the second step, all individuals performed arithmetic tasks on a computer. For both tasks, it was an inverted "U" behavior, with an improvement in the psychomotor performance at each increment on the workload up to 40% of the VO2max.

The aerobic fitness is connected with aspects of cognition in children but it is not explored. A meta-analysis conducted on 16 studies using true experimental designs found a positive relationship between physical activity and cognition or academic achievement in school-age children (Sibley, B.A , and Etnier, J.L., 2003). These findings suggest that fitness may be related to improvements in cognitive function, but do not show the mechanisms by which aerobic fitness may affect brain and cognition in children. Also, other factors such as the socio-economic status may contribute to children's physical activity participation, making it difficult to determine the influence of fitness, on cognitive function during the early stages of the human life span.

Method

The aim of the present study was to investigate the effect of physical activity on reaction time in children. 40 boys of six to eight grade (aged 13 to 15 years) were selected for the study after receiving approval from the Ethics Committee and informed consent on the part of parents. The study was conducted in accordance with the Declaration of Helsinki, and the protocol approved by the

Ethics Committee of the Sports University of Tirana. The subjects were divided into two groups. The first group consisted of physically active boys who engaged in sports training for 2 hours every day as members of a local football team. The second group consisted of 20 inactive boys selected from a local secondary school and did not participate in any kind of sports activity. First, participants of both groups were subjected to anthropometric measurements. Height of the participants was measured barefoot to the nearest 1 mm. Weight of the participants was measured in without shoes and underwear with an electronic scale to the nearest 0.1 kg. BMI was calculated using a computer software as body weight in kilograms divided by the square of height in meters, and the percentage of body fat was measured with a fat caliper. Participants were also subjected to an IQ Test consisting of 30 questions fitted for their age group, to measure their level of intelligence. While to gauge their ability to react in relation to time and space, subjects were subjected to an audio reaction time test (beep test) while exercising on a treadmill. Subjects were asked to press a key every time they heard a "beep" sound. The Bruce Treadmill test protocol was used to measure at what point during the test, participants had their best reaction time. Subjects were made to run on a treadmill till to exhaustion. At timed stages during the test, the speed (km/hr) and grade of slope (%) of the treadmill were increased. At stage 1, the treadmill's speed was set to 2.74 km/hr and the slope grade was 10%. 3 minutes into the test, the speed was adjusted to 4.02 km/hr and the slope to 12%, and after 6 minutes into the test, speed increased to 5.47 km/hr and the slope to 14%. When children were not able to continue the test, normally this should be within 9 and 15 minutes of the test (Bruce, R.A., 1972), the assistant stopped the stopwatch and the test was ended. VO2 max was calculated using the formula as follows:

$$VO2\ max = 14.8 - (1.379 \times T) + (0.451 \times T^2) - (0.012 \times T^3)$$

"T" is the total time of the test expressed in minutes and fractions of a minute.

Results

More than 30 percent (7 boys) of the 20 inactive boys didn't fulfill the entire test due to the fact that they were exhausted. The BMI had a strong relationship with the outdoors Physical Activity and the difference between the active and inactive for the BMI was significant ($p < 0.01$). The BMI was of 26 kg/m^2 for the inactive children and 18.6 kg/m^2 for the active children. The IQ tests showed a percentage of 54% for the inactive children of the right answer and a 48 percent for the active children statistically not significant ($p < 0.01$). BMI and IQ results for both groups are presented in (Table 1 and Table 2).

Table 1. *BMI and IQ Test results of the Active Children*

Name/Surname	Weight/kg	Height/m	BMI	Timeof training/month	IQ Test results Percentage %
Average	**49.84**	**1.60**	**18.45**	**24.00**	**48.17**
SD	**9.9191**	**0.0886**	**2.2**	**0.00**	**7.9215**

Table 2. *BMI and IQ Test Results of the Inactive Children*

Name/Surname	Weight/kg	Height/m	BMI	VO2max	IQ Test results Percentage %
Average	**73.365**	**1.6715**	**26.29**	**18.848**	**54.5**
SD	**5.549**	**0.0798**	**1.521**	**1.992**	**5.4**

The results of the reaction time before the exercise were of 473 m/s for the active children and of 408 m/s for the inactive children, the difference was statistically significant ($p < 0.01$). The reaction time was of nearly the same values till the end of the test, the differences were not significant ($p < 0.01$). Reaction time results for both groups are presented in (Table 3 and Table 4).

Table 3. *Reaction Time Results of the Active Children*

	Cardiac Frequency	Reac time before	Cardiac Frequency	Reac time 2	Cardiac Frequency	Reac time 3	Cardiac Frequency	Reac time 4	Cardiac Frequency	Reac time 5
Average	86.85	0.443	110.5	0.496	146.65	0.45	162.1	0.502	190.85	0.406
SD	3.93	0.086	7.59	0.12	11.5	0.08	14.17	0.11	12.12	0.05

Table 4. *Reaction Time Results of the Inactive Children*

	Cardiac Frequency	Reac time before	Cardiac Frequency	Reac time 2	Cardiac Frequency	Reac time 3	Cardiac Frequency	Reac time 4	Cardiac Frequency	Reac time 5
Average	85.6	0.431	123.15	0.498	161.05	0.44	177.85	0.502	197.85	0.409
SD	2.703	0.045	7.71	0.048	7.89	0.04	7.25	0.06	3.82	0.053

The correlation between cardiac frequency and reaction time for both groups is presented in (Figure 1 and Figure 2).

Figure 1. *Active children reaction time and Cardiac Frequency*

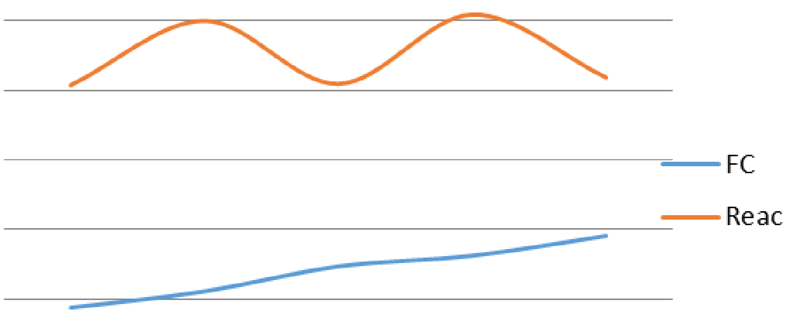
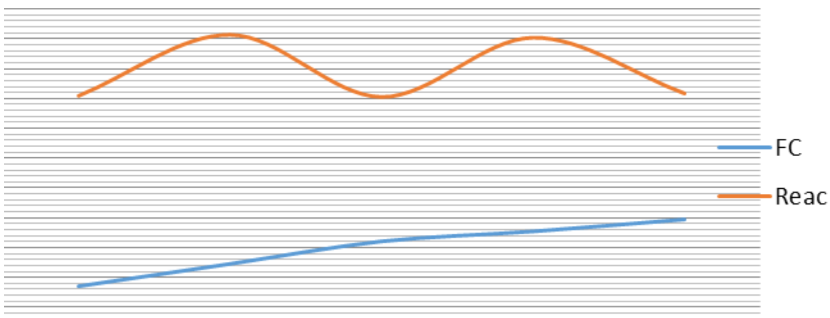


Figure 2. *Inactive children reaction time and Cardiac Frequency*



Discussion

The study of the relationship between physical fitness, and more specifically aerobic fitness, and cognition dates back several decades. The questions of whether or not such direct relationship does indeed exist, to what extent, and what variables make this connection the strongest have been the subject of many studies.

For the purposes of this paper, it is important to define exercise and cognition. According to the Webster's online dictionary the definition of exercise is: "the bodily exertion for the sake of developing and maintaining physical fitness" (The Journals of Gerontology Series A: 2003). Many different definitions of exercise do exist though. Another commonly used definition from Webster's dictionary: "something that is performed or practiced in order to develop, improve, or display a specific power" (The Journals of Gerontology Series A: 2003). This definition does not include physical fitness, but leaves it open by using the word something.

For this paper, the first meaning will be the one utilized here. Exercise and fitness training are used interchangeably, along with some other substitutes in this paper. All the descriptions are in line with the above-presented definition of exercise. Although different type of cognition tests reviewed in this paper test various parts of the information processing, this definition sufficiently addresses the meaning of cognition used for the purposes of this paper.

Other researchers have, either explicitly or implicitly, assumed that fitness effects would be most likely observed in tasks such as simple reaction time or finger tapping, which presumably tap low-level central nervous system function uncontaminated by subject strategies or high-level cognition (Dustman, R.E., Ruhling, R.O., Russell, E.M., Shearer, D.E., Bonekat, W., Shigeoka, J.W., Wood, J.S. & Bradford D.C., 1984). This theoretical hypothesis is known as the speed hypothesis. Still, other researchers have suggested that fitness effects might be most readily observed for visuospatial tasks (Stones, M., & Kozma, A., 1989), because visuospatial processes have been demonstrated to be more susceptible to ageing than verbal skills. This is termed as the visuospatial hypothesis.

Finally, Kramer et al. (Kramer, A.F., Hahn S., Cohen N.J., Banich M.T., McAuley E., Harrison C.R., Chason J., Vakil E., Bardell L., Boileau R.A., & Colcombe A., 1999) argue that better fitness would be reflected in enhancements in executive-control processes such as coordination, inhibition, scheduling, planning, and working memory. Executive-control processes and the brain areas that support them have shown disproportionate sensitivity to aging. This is the executive-control hypothesis.

The action of the physical exercise on the cognitive function can be direct or indirect depending on age or other causes. The mechanisms that actuate in a direct way increasing the velocity of the cognitive processing would be an improvement in the cerebral circulation and in the synthesis and degradation of neurotransmitters in the brain. Besides these direct mechanisms, there are other mechanisms such as a decreasing blood pressure, decrease in the LDL, etc., that seem to have an indirect action, improving this function. Added to an improvement in the general function capability it has a reflection as an increase in the quality of life. The researchers have suggested some mechanisms which are responsible by the mediation of the effects of the exercising on the cognitive functions. It is believed that the physical exercise could increase the blood flow into the brain, consequently the Oxygenation, making an improvement in the cognitive function. Another hypothesis that has been formulated is about the effects of the oxidant stress on the CNS, because the aerobic physical exercises maybe increases the activity of the oxidant enzymes, as in other tissues such as the skeletal muscle, increasing the defense against the damages caused by oxygen specimens as Radák et al show in their article (Radák, Z., Kaneko, T., Tahara, S., Nakamoto, H., Pucsok, J., Sasvári, M., et al., 2001).

The hypothesis that the physical exercise per se increases the release of several neurotransmitters, such as the nor epinephrine and its precursors (Ebert, M.H., Post, R.M., Goodwin, F.K., 1972; Strüder, H.K., Weicker, H., 2001), in the serotonin (Bortz, W.M. 2nd, Angwin, P., Mefford, I.N., Boarder, M.R., Noyce, N., Barchas, J.D., 1981; Schuit, A.J., Feskens, E.J., Launer, L.J., Kromhout, D., 2001) and β-endorphin (Etnier, J.L., Salazar, W., Landers, D.M., Petruzzello, S.J., Han, M., Nowell, P., 1997) blood concentration after an acute exercise session, cannot be rejected.

Our data also suggest that there is more research necessary to actually do an examination of brain structure and functioning, and the impact of interventions such as children fitness and cognitive training. Although many theories exist on how to approach the study of correlation between cognition and exercise, a formation of one main theory will facilitate better results in the future. Nevertheless, theoretical accounts of fitness effects on human cognition can only rarely be neatly and precisely fit into the processing components of existing theories.

The differences between the IQ test were of in the favour of those that don't participate in sports. The BMI had a strong relationship with the outdoors Physical Activity. The relationship with the IQ test and with the reaction time was not significant, however the physical activity affected the reaction time positively in both groups. The results of reaction time during the Treadmill protocol showed that it improves at the pulse of 146 bpm to the active children and at 155 bpm to the inactive children. The results of the study did not reveal a significant correlation between regular physical activity and intelligence. Furthermore, no significant correlation was found between physical activity and reaction time. Several factor might contribute to these results. It is possible that the duration and intensity of the physical activity was not sufficient to elicit cognitive improvements. Additionally, other factors such as genetics, socio-economic status and educational opportunities may play a more significant role in determining intelligence and reaction time in children. Further research is warranted to explore potential indirect effects of physical activity on cognitive abilities, such as improvements in mood, attention, and overall well-being. In conclusion, these findings emphasize the importance of considering multiple factors when examining cognitive abilities in children and highlight the need for further research in this area.

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submitted 22.08.2023;
accepted for publication 20.09.2023;
published 8.10.2023

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