

## **Adverse Effects of Passive Smoking on Executive and Pulmonary Functions in School Aged Children in Egypt**

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### **KEYWORDS**

Passive smoking, Executive function, Pulmonary functions, School Children.

### **ABSTRACT**

**Background:** Passive smoking is the leading preventable cause of many issues related to physical and mental health constraints in children.

**Objectives:** This study aims to investigate the effect of passive smoking on executive and pulmonary functions in school-aged children.

**Methods:** An observational (case control) study including 240 school aged children of both sexes (group A includes 120 passive smoking children and group B includes 120 non-passive smoking children), with age ranged from 8-12 years. For both groups, executive functions were evaluated using the Tower of Hanoi, Stroop colored word test, and Trail-making test (A). In addition, pulmonary functions have been investigated through (forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) were measured by the spirometer.

**Results:** There was a significant decrease of executive function tests due to passive smoking ( $p < 0.001$ ). Also, there was a significant reduction in all measurable pulmonary function tests (FVC and FEV1) in passive smoking children compared with non-passive smoking children ( $p < 0.001$ ).

**Conclusion:** Passive smoking has an adverse impact on executive and pulmonary functions in school-aged children.

## **Introduction**

Passive smoking (PS) is defined as a circumstance in which a person who does not smoke is exposed to the smoking of another individual even though he or she does not smoke, and it was responsible for 1.2 million cancer deaths, 60,000 respiratory infection fatalities in children, and 1.5 million deaths from chronic respiratory disorders<sup>1</sup>. More than 7000 compounds, including cyanide, nicotine, arsenic, and carbon monoxide, can be found in cigarette smoke. Despite efforts by health organizations to increase awareness regarding the negative effects of smoking, 40% of children globally are exposed to these toxins<sup>2</sup>.

A large proportion of the world's population is considered passive smokers as a result of tobacco inhalation, which accounts for about a third of the world's population. The prevalence of diseases caused by passive smoking every year represents around 1% of all diseases, and deaths account for 0.6 million deaths worldwide<sup>3</sup>. According to the findings of research carried out throughout 192 nations, about 40% of children and 36% of fetuses were exposed to PS<sup>4</sup>.

The term "executive functions" (EF) refers to a group of neurocognitive abilities such as goal-directed problem solving, working memory, inhibitory control, and set shifting/flexibility. It also heavily relies on prefrontal cortex-related neural networks. Individual variations in EF have recently been accepted as a major indicator of future social and cognitive development. According to studies, EF is influenced by both proximal and distal developmental factors, including background socioeconomic status, language, way of life, parental care, interactions between genes and sleep<sup>5</sup>.

Cognitive ability and mental health are part of the relationship between smoking and neural development based on the various evidences of researches<sup>6</sup>. PS has been associated with behavioral and cognitive issues in children, including attention issues, cognitive and intellectual deficiencies<sup>7</sup>.

Children's lung function measures are negatively influenced by passive smoking because they are more susceptible to its effects due to their faster breathing rates and greater pollutant inhalation rates compared to adult<sup>8</sup>. PS adversely affects children both immediately and over time, leading to frequent hospitalizations, lower respiratory tract infections, a rise in asthma prevalence, deteriorated pulmonary function, and adult chronic obstructive disease. These problems may become worse due to parental long-term smoking and other risk factors, such as premature birth<sup>2</sup>.

Identification of the detrimental effects of children's exposure to PS is very important because it is so pervasive in society, represent a serious issue for the community's health, and affects brain and respiratory development in children. It is recommended to increase awareness in society to protect the emerging generation from the hazards of passive smoking and prevent it in every possible way for the future of our home. As passive smoking can affect the functions of the brain and lungs and lead to respiratory and mental problems, the purpose of this research is to investigate the effect of passive smoking on executive and pulmonary functions in school-aged children.

## **Methods**

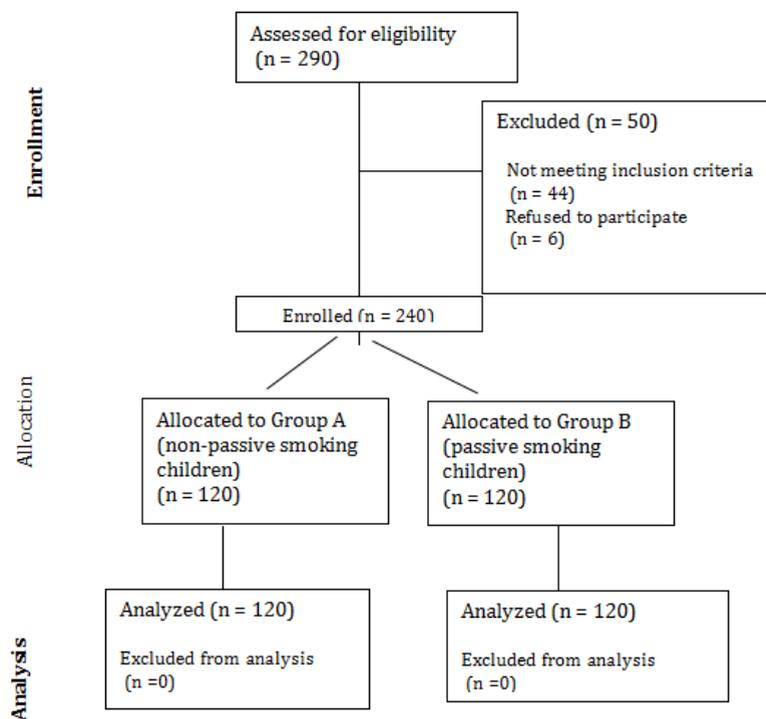
### **Sample size calculation**

To avoid a type II error, a preliminary power analysis was conducted considering executive functions as a primary outcome with the following parameters: [power  $(1-\beta) = 0.80$ ,  $\alpha = 0.05$ , effect size = 0.379]. This effect size was calculated using mean and SD of a previous similar study using same

measuring tools and procedures 9. The calculation determined a sample size of 111 which will be increased by 8% up to 120 for each group for overcome the expected dropout. G\*power software (3.1.9.2) was used for sample size calculation.

## Participants

Two hundred forty children fulfilled the inclusion criteria of this observational (case control) study (Figure 1). They were recruited from Primary Schools, Al-Fayoum Governorate, Egypt. The participating children's inclusion criteria included selecting an age range between 8 -12 years, they had no difficulty comprehending the instructions. Their intelligence quotient not less than 75% according to the Raven's colored progressive matrices test. According to the exclusion criteria, it included children who had a history of neurological or chronic illnesses, psychological problems, obvious musculoskeletal issues, visual or auditory deficiencies, obvious motor development complications, or who had taken any medications that might have impacted their level of arousal and awareness. Age matched children in this study were enrolled in two groups: Group A (120 non-passive smoking) and Group B (120 passive smoking children). All parents of children signed an informed consent form.



**Figure 1: Flow chart of the study**

## Methods

Children were assessed using the following: -

- 1- **Questionnaire:** Including personal information such as the child's name, age, height, weight, gender, address, school grade, parents phone number, the parent's employment status and educational level (as determined by a socioeconomic sheet), and whether any of the parents smoke? How many years have (mother, father or, both) smoked cigarettes or other products?

and how many cigarettes each day?9. This questionnaire filled by children and their parents, as appropriate.

## **2- For evaluation of executive functions:**

### **a- Tower of Hanoi (TOH):**

It is a reliable performance test used to measure executive function. The game consists of threading discs arranged in descending size from bottom to top on a peg. Begin by having all disks on one peg. One disk at a time may be moved to another peg. A larger disk cannot go on a smaller disc. Keep track of the number of moves<sup>10</sup>.

### **b- Trail making test part A (TMT A):**

It is used to evaluate both visual scanning as well as processing speed. The subjects are given a page with a variety of numbers on it, and they have been instructed to link the numbers in a sequential fashion by drawing lines<sup>11</sup>.

### **c- Stroop colored word test (SCWT):**

An internet-based Stroop colored word task (Online version – cognitivefun.net-test2) <sup>12</sup>. It is used to measure selective attention and inhibitory control. There were different colors (eg., red, green, blue) used for showing words. In order to identify the font's color as rapidly as possible, participants had to focus on the word's meaning while pressing the key that referred to that color. There were congruent and incongruent trails<sup>13</sup>.

## **3- For evaluation of pulmonary functions:**

Spirometer (Contec, China SP10BT): It was used to assess forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) according to the recommendations of the American Thoracic Society standards <sup>14</sup>. The children were given an explanation of the test. The test was conducted after 20 minutes break from any vigorous activity or exercise. The child was seated with the trunk extended by 90 degrees and the neck in neutral alignment. A mouthpiece was placed over the child's mouth after he inhaled as much as he could. He then exhaled as forcefully and quickly as he could, making sure to empty his lungs completely<sup>15</sup>.

## **Statistical analysis**

Unpaired t-tests and Chi squared tests were used to compare the characteristics of the subjects between groups for numerical data and categorical data, respectively. Normal data distribution was checked using the Kolmogorov-Smirnov test. To examine the homogeneity between groups, Levene's test for homogeneity of variances was used. An Unpaired t-test was conducted to compare pulmonary function and executive functions between groups. For comparison of median values of the number of mistakes in the trail- making test between groups. A Mann-Whitney test was conducted. For all statistical tests, the level of significance was set at  $p < 0.05$ . The statistical package for social studies (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA) was used for all statistical analysis.

## Results

### Subject characteristics:

Participants in this study were 240 school-aged children of both sexes, their ages ranged between 8 - 12 years. 120 children were non passive smokers (group A), and 120 children were passive smokers (group B). Table (1) demonstrated the characteristics of the subjects in both groups. There was no significant difference in subject characteristics between groups ( $p > 0.05$ ).

**Table 1.** Subject characteristics of non-passive smoker (Group A) and passive smokers (Group B):

	Group A	Group B		MD	t-value	p-value
	Mean $\pm$ SD	Mean $\pm$ SD				
Age (years)	10.38 $\pm$ 1.14	10.58 $\pm$ 1.07	-0.2	-1.36	0.17	
Weight (kg)	34.31 $\pm$ 7.61	35.24 $\pm$ 8.89	-0.93	-0.87	0.38	
Height (cm)	134.82 $\pm$ 9.61	134.24 $\pm$ 8.76	0.58	0.49	0.62	
BMI (kg/m <sup>2</sup> )	18.58 $\pm$ 1.21	18.04 $\pm$ 1.53	0.54	1.46	0.15	
Sex, n (%)						
Girls	67 (56%)	67 (56%)		( $\chi^2 = 0$ )	1	
Boys	53 (44%)	53 (44%)				
Grade III	57 (47.5%)	66 (55%)		( $\chi^2 = 2.28$ )	0.13	
Grade II	58 (48.3%)	51 (42.5%)				
Grade I	5 (4.2%)	3 (2.5%)				
Years of smoking		15.26 $\pm$ 2.67				
Number of cigarette/days		25.93 $\pm$ 3.68				
Heaviness of smoking n (%)						
Heavy		63 (52.5%)				
Moderate		57 (47.5%)				

SD, standard deviation; MD, mean difference;  $\chi^2$ , Chi squared value; p value, probability value.

### Passive smoking and executive functions:

#### Tower of Hanoi

There was a significant increase in Tower of Hanoi test time and number of steps for group B in relation to that of group A ( $p < 0.001$ ). (Table 2).

#### Trial Making Test A

There was a significant increase in trial making tests time-parts A of group B compared with that of group A ( $p < 0.001$ ). (Table 2).

#### Stroop colored word test

There was a significant decrease in the congruent and incongruent correct ratio of group B

compared with that of group A ( $p < 0.001$ ). There was a significant increase in congruent and incongruent response times in group B compared with that of group A ( $p < 0.001$ ). (Table 2).

**Table 2.** Comparison of executive functions between non-passive smoker (Group A) and passive smokers (Group B):

	Group A		Group B		MD	t-value	p value
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD			
<b>Tower Of Hanoi</b>							
Time (sec)	93.82 $\pm$ 25.43	215.67 $\pm$ 28.81	215.67 $\pm$ 28.81	215.67 $\pm$ 28.81	$\pm$ -121.85	-34.73	0.001
Number of steps	19.39 $\pm$ 3.13	31.69 $\pm$ 3.46	31.69 $\pm$ 3.46	31.69 $\pm$ 3.46	-12.3	-28.88	0.001
<b>Trial Making Test time (sec)</b>							
Part A	78.02 $\pm$ 31.96	97.53 $\pm$ 38.73	97.53 $\pm$ 38.73	97.53 $\pm$ 38.73	-19.51	-4.25	0.001
<b>Stroop colored word test</b>							
Congruent correct Ratio	0.95 $\pm$ 0.11	0.82 $\pm$ 0.15	0.82 $\pm$ 0.15	0.82 $\pm$ 0.15	0.13	7.39	0.001
Incongruent correct Ratio	0.86 $\pm$ 0.18	0.71 $\pm$ 0.19	0.71 $\pm$ 0.19	0.71 $\pm$ 0.19	0.15	6.05	0.001
Congruent response time (msec)	4012.02 $\pm$ 1625.67	5039.80 $\pm$ 1777.52	5039.80 $\pm$ 1777.52	5039.80 $\pm$ 1777.52	$\pm$ -1027.78	-4.67	0.001
Incongruent response time (msec)	4718.92 $\pm$ 1963.99	5731.32 $\pm$ 2262.69	5731.32 $\pm$ 2262.69	5731.32 $\pm$ 2262.69	$\pm$ -1012.4	-3.71	0.001

SD, standard deviation; MD, mean difference; p value, probability value.

**Effect of passive smoking on pulmonary functions:**

There was a significant decrease in FVC and FEV1 in group B compared with that of group A ( $p < 0.001$ ). (Table 3)

**Table 3.** Comparison of FVC and FEV1 between non-passive smoker (Group A) and passive smokers (Group B):

	<i>Group A</i>	<i>Group B</i>		t- value	p value
	Mean ± SD	Mean ± SD	MD		
FVC (L)	2.23 ± 0.61	1.85 ± 0.46	0.38	5.57	0.001
FEV1 (L)	2.04 ± 0.39	1.65 ± 0.40	0.39	7.56	0.001

### Discussion

The aim of this study was to investigate the effect of PS on executive and pulmonary functions in school aged children. The results showed that there are adverse effects on the executive function as evidenced with increased response time and increased number of mistakes throughout all investigated cognitive tasks. Moreover, the adverse effects of PS on pulmonary functions were confirmed through forced vital capacity and forced expiratory volume in one second.

Interestingly, there were several studies showed the adverse effects of PS on executive functions.

Oh et al. revealed an association between poorer executive functions and children's exposure to tobacco smoke at age 8 years<sup>16</sup>. Also, Chastang et al. stated that there were behavioral issues in persons who exposed to environmental smoking<sup>17</sup>. The increased number of errors in executive function tasks might be related to the effect of tobacco smoke on brain function and structure evidenced with ineffective activation of prefrontal cortex<sup>18</sup>. Unfortunately, nicotine and carbon monoxide have been found to impair brain development in the fetus<sup>19</sup>.

Our findings and the results of other studies that are consistent may be related to the fact that the fetus and child are exposed to numerous hazardous chemical substances when exposed to smoking pre- and post-natal, which limits the growth of both the body and head<sup>20</sup>. It has been demonstrated that in active and passive smokers, nicotine can cross the placenta, get into the fetus' blood stream, and then build up in its compartments. This process occurs in the early stages of pregnancy, nearly from the seventh week<sup>21</sup>.

Regarding the adverse effects of PS on pulmonary functions, this study showed reduced forced expiratory volume in one second and forced vital capacity. These findings were reinforced by those of Wang et al. who found that children's pulmonary function and respiratory disorders are significantly impacted by passive smoking<sup>22</sup> another study also reported that there was a deterioration of respiratory function in passive smoker children<sup>23</sup>. Reduced pulmonary functions, particularly lower FEV1/FVC

ratios and higher airway resistance, have been linked to mothers who smoked throughout pregnancy<sup>26</sup>. In a study performed on primary and secondary-level students in Mexico City, secondhand smoking was correlated with worsening respiratory symptoms, and a decline in spirometric pulmonary measures<sup>24</sup>.

These results are consistent with other literature which showed reduced pulmonary functions after exposure to tobacco smoke which might be related to the altered lung structure and maturation, reduced lung branching, increased airway resistance, reduced airflow, and increased percentage for allergy exposure <sup>25</sup>.

On the other hand, our results do not match with the outcomes and statistical analysis of a previous study that reported that school-aged children's lung functions are not significantly related to passive smoking because this study conducted on athlete children who have more lung functions than age-related non-athlete peers, suggesting a feasible positive effects of sportive activities on the lung functions<sup>26</sup>.

Nevertheless, previous literature showed a relationship between aerobic capacity and executive function <sup>27</sup>. Thus, the reduced executive function in our study might be associated with decreased pulmonary function and reduced oxygen allocation for brain activity. It is important to mention that physical or sports activities can mitigate some negative consequences of passive smoking such as inflammation<sup>28</sup>. which consequently reflects on improving pulmonary and executive functions so we recommend children in this age group to participate in sports activities to compensate for the negative effects of passive smoking.

This study's findings emphasize the need for family counseling programs to provide early intervention against the negative effects of passive smoking, educating parents on protecting their children from these effects and keep their homes smoke-free (This is in agreement with the UN child charter, which recommended the freedom to breathe a clean air). Smoking-control efforts are essential to reduce children's exposure to this risk factor<sup>229</sup>. Also, this study highlights the significance of the medical field in general and the field of physiotherapy in particular in serving the community and focusing on issues such as passive smoking<sup>30</sup>. Additionally, this study may be helpful to the field of physical therapy, as it will assist physical therapists in creating treatment programs and managing children who have physical issues, pulmonary problems, or executive function deficits. This study also emphasizes the need for more studies on those children to see how much passive smoking usually affects their lives as they get older.

## **Conclusion**

Passive smoking children had lower performance in executive function tests and pulmonary function measures than non-passive smoker children. These findings point out the dangers of passive smoking on children, which can seriously harm their health, especially their respiratory and executive functions, which can affect their physical, academic performance and quality of their lives.

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