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REVIEW ARTICLE

Assessment of alpha emission in the saliva of the smokers using CR-39 (SSNTDS)

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Abstract:

Background: The concentration of radionuclides in the saliva and blood samples is a good indicator of the human body's radioactive contamination. The objective of the current study was to design a cross-sectional study to assess the alpha particles emitted from the smoker and nonsmoker saliva and blood samples.

Materials and Method:The saliva and blood samples were collected from 88 healthy male and female smokers and non-smokers aged 18-82 years old. In saliva and blood samples from smokers and nonsmokers, the alpha track density was determined utilizing the efficient fission track analysis approach with the CR-39 nuclear track detector.

Results: High mean value of alpha track density was significantly seen in smoker saliva and blood samples compared to nonsmoker samples, with percentage differences of 23% and 9%, respectively. There was a positive correlation between smoker age and the alpha emission rate in blood and saliva samples.

Conclusion: The smoker and nonsmoker saliva and blood samples did not have equal distribution of alpha track density. According to their standardized coefficients (ß), in saliva and blood samples, the stronger significant impact of alpha emission rate was seen at ß = 0.318 with age interval (70-82) in saliva samples. While the lowest was found at ß = 0.156 with age interval (44-56) in the blood sample.

Keywords: alpha emission, saliva, blood, smoker, CR-39 detector

Introduction

Alpha particles are emitted by radionuclides released from naturally occurring radioactive materials [1, 2]. This type of ionizing radiation is highly dangerous and more effective than radiation such as X-rays and gamma rays. It poses a greater risk to human tissues due to its high charge and density. Both 214Po and 218Po, which belong to the Radon series, are alpha emitters. These elements are the primary sources of internal radiation exposure to the body. [3]. The study focused on assessing the potential harm caused by alpha particles emitted from cigarette smoking. It quantified the magnitude of the increase in radiation damage resulting from smoking habits [4]. Upon entering the body, alpha particles are transported to various organs via the bloodstream, where they settle and accumulate, particularly in organs such as teeth and bones.The potential effects of alpha particles on the human body cannot be disregarded. These effects can be categorized into two types, with the first being acute effects. Two categories can be used to describe the effects of radiation exposure: acute effects, which happen when the body is exposed to high radiation doses for a brief period of time, and delayed effects, which happen after long-term exposure to low radiation doses.

While delayed effects can result in a variety of symptoms, such as thyroid cancer, breast cancer, leukemia, infertility, and genetic abnormalities in humans, acute consequences appear in all of the body's organs and systems [5-6]. Previous research has identified additive, multiplicative, and supra-additive interactions between smoking cigarettes and radiation

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exposure (alpha particles) [7-20]. There have been more claims in recent years on the potential of a supramultiplicative model [12, 21-25]. It was also discussed that the impact of smoking on radiosensitivity varies depending on certain factors, such as smoking frequency [26-29].

Materials and method

The saliva and blood samples were collected from 88 healthy male and female smokers and non-smokers who agreed to participate in this research, ages 18–82. In the cross-sectional study, subjects were divided into two sections; the first one consisted of 46 smoker persons, and the second section (selected cases) consisted of 42 non-smoker persons. The saliva samples were collected in a petri dish. Each participant had approximately 5 ml of blood extracted and placed in vacutainer tubes treated with ethylene diamine tetraacetic acid (EDTA). The tubes were regularly turned to mix the blood and EDTA in order to prevent clotting. To prevent coagulation, the tubes were repeatedly flipped to mix the blood and EDTA. After that, every sample was kept in a freezer, with a temperature range of 2 to 6°C. Samples were moved from the cold box to the Physics Department's lab at the Baghdad University College of Education for Pure Sciences so that they could be analyzed. Solid-state nuclear track detectors (SSNTDA) with a thickness of 500 µm are used to determine the alpha track density.

Solid-state trick detectors are electrical insulating material with a resistance quality ranging from 106 to 1020 Ohm. When charged particles like alpha particles, fission matter, and protons pass through them, they create narrow paths of radiation called hidden tracks. These tracks depict the kinetic energy of the descending particles and their respective classifications. The detector was utilized for detecting both charged particles and neutrons [30]. Detectors can be divided into two groups according to the materials they are made of. The first type of detector is composed of organic solids, such as polymers, while the second type consists of inorganic solids, such as glass and crystal [31]. Polymeric plastics, such as uranium, radium, and radon, are frequently employed for measuring exhaled alpha particles from radionuclides. These plastics are chosen for their straightforwardness, sensitivity, durability, cost-effectiveness, efficiency in detecting alpha particles, ease of handling and processing, compact size, and ability to provide a cumulative response over extended periods. An example of such a plastic is the CR-39 detector, which is named after Columbia Risen [32] and is obtained from Pershore Moulding LTD Company in the UK. CR-39 is a chemical compound with the molecular formula $C_{12}H_{18}O_7$.. It is synthesized through the polymerization of the oxydi-2,1-ethanediyl, di-2-propenyl ester of carbonic acid. The detector exhibits a weak bond, resulting in a heightened sensitivity to all forms of radiation [33].

A digital thermometer was used to measure the temperature of the smoker and non-smoker persons prior to collecting samples. Saliva samples were taken about an hour into the home visit procedure, making sure that neither the smoker nor the non-smoker had eaten or drunk anything during that time [34, 35]. The saliva samples were distributed among CR-39 detectors and left for 150 days to achieve radiation equilibrium. Subsequently, they were then labeled with the numbers that corresponded to the research participants and kept in plastic petri dishes. While the CR detector is immersed in blood samples with 5 ml and left for 150 days [36]. Etching the SSNTD material with a chemical solution is the most efficient method for track observation. This solution targets the damaged material and increases the size of the original track, making it visible under an optical microscope. This research employed a sodium hydroxide solution (NaOH) at a temperature of 60°C for a duration of 5 hours for the purpose of chemical etching. The etchant solution was prepared and utilized by following the prescribed equation:

(1)Where

The volume of the chemical etchant was 250 ml, consisting of an NaOHsolution with a normality of 6.25 N. The apparatus is sealed, with the exception of a small vent located at the top of the condenser tube. This vent ensures that there is no alteration in the concentration of the etchant during the etching process, as it prevents evaporation.

In addition, the density of fission tracks that were chemically etched was measured using an optical microscope (MT 4310H, Meiji, Japan) capable of providing a magnification of 400x. The track density was quantified using the below equation [37, 28]: For every detector, the tracks' average was calculated. Equation (2) was used to get the track density (ρ) for each detector:

ρ= (N Bavg)/A (2)

Where :

ρ: The track , s density (Track .cm-2)

N Bavg : The average total number of tracks

A: The field of view , s area (0.027 cm2)

The efficiency of CR -39 was found Eq. (3)

E=1- VB/VT (3)

Where:

E□85%

VB : Bulk etch rate (µmh-1)

VT : Track etch rate (µmh-1)

The alpha emission rate was consider using:

Eα = (E(ρs-ρb))/T

Where:

Alpha partical emission rate (Bq cm-2) is represented by Eα

E□CR-39 efficiency

ρs:Alpha track density of the saliva and blood samples

ρb:Number of bacground track in the detector (track cm-2) 3.22

T: Exposure time (day) (39)

Statistical Analysis

The statistical program of the social sciences (SPSS version 24.0) was used to assess the research results statistically. To describe the characteristics of the statistical variable, it was initially computed. Median, mean, min, max, and interquartile range (IQR) were depicted to record the data distribution. The percentage differences were determined to find the differences of concentration between smoker and non-smoker saliva and blood samples. The unpaired t-test was used to determine P values. Differences between the study parameters are deemed very significant when the P value is less than 0.001 and significant when $P < 0.05$. An insignificant association was discovered at a p-value ≥ 0.05. Linear regression models were performed to assess the association between the alpha emission rate in smokers and nonsmokers with age intervals.

Results

Specific characteristics of 88 smokers and non-smokers are provided in Table 1. The mean value of participant age was

33.22 ± 2.67 years old, ranging between 18 and 82 years.In addition, most of the interval age was 70-82 (27%). Regarding sex, a high percentage value was recorded for the male (61%). The majority of the participants were smokers (52%).

Table 1: The demographic characteristics

Parameters	Characteristics	Frequency	Percentage
Age Inteval	18-30	12	14
	31-43	17	19
	44-56	15	17
	57-69	20	23
	70-82	24	27
	Total	88	100
Gender	Famel	34	39
	Male	54	61
	Total	88	100
Smoker Case	Smoker	46	52
	Non-Smoker	42	48
	Total	88	100

The track density for alpha particle emissions in the unit mBq/cm² was established using a CR-39 detector. The statistical description of alpha track density in smoker and non-smoker saliva and blood samples is demonstrated in Table 2. The average background alpha track density at various points of the CR-39 nuclear track detector equals 3.22 tracks cm^{-2} in this study. The overall trend in all saliva and blood samples shows that the value of the mean measurement of alpha track density in the saliva sample of a smoker was higher (16.41±0.01) compared to that of non-smoker saliva samples, with 4.39 times greater significance (t=-2.365, $p < 0.001$). Similarly, the difference in alpha track density in the blood samples of smokers was 10.69 times higher than in non-smokers. The alpha track density in smoker saliva samples differed from that in blood samples by 26%. While the percentage differences between the alpha track density of non-smoker saliva and blood samples were 20%.

Table 2: Descriptive statistics of alpha track density in smoker and nonsmoker saliva and blood samples

Statistical values	Saliva Track density (Track. cm^{-2})		Blood Track density (Track. cm^{-2})	
	Smoker n=46	Non-Smoker n=42	Smoker n=46	Non Smoker n=42
Mean	16.41	3.74	13.04	1.22
SE	0.01	0.01	0.02	0.04
Median	13.22	4.03	11.11	2.04
SD	0.34	0.35	0.03	0.02
Min ±SD	7.15±0.04	1.10±0.05	4.67±0.01	0.3±0.01
Max ± SD	17.73±0.04	7.26±0.03	14.33±0.05	2.02±0.11
IQR	6.20-15.84	1.3-6.56	3.22-12.08	0.24-1.94
Unpaired t - test	t = -2.365, p < 0.001		t =-3.595,p < 0.001	

In smoker saliva and blood samples, the range values (min to max) of alpha track density were recorded higher than the range values (min to max) of non-smoker saliva and blood samples. On the other hand, the highest value of interquartile range (IQR) was shown at (6.20–15.84) for the saliva samples of smokers. While the lowest value was recorded for the non-smoker blood samples (0.24-1.94).

The percentages of alpha emission rate in saliva and blood samples in smokers (70% and 71%, respectively) are greater than those in non-smokers (30% and 29%), respectively. Thus, the degree of alpha emission rate in saliva and blood samples was ranked as follows:smoker > non-smoker, as shown in Fig. 1. A significant positive correlation was discovered between alpha emission rate in saliva and blood samples in smoke ($r = 0.332$ and 0.213, respectively, $p < 0.05$). Similarly, the same result was found in nonsmokers ($p < 0.05$).

Fig. 2 displays the results of the saliva and blood samples based on the gender of the participants in this study. Significant increments of alpha emission in saliva and blood samples were discovered for males compared to females at 1.01 and 1.63 times, respectively. The main reason behind this result can be imputed to the fact that the total blood volume in males is usually higher than in females [40, 41].

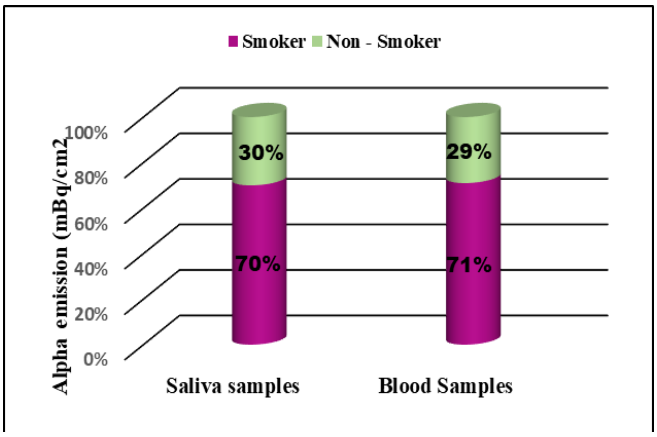

Fig. 1: The percentage values of the alpha emission rat in saliva and blood samples for smoker and non smoker

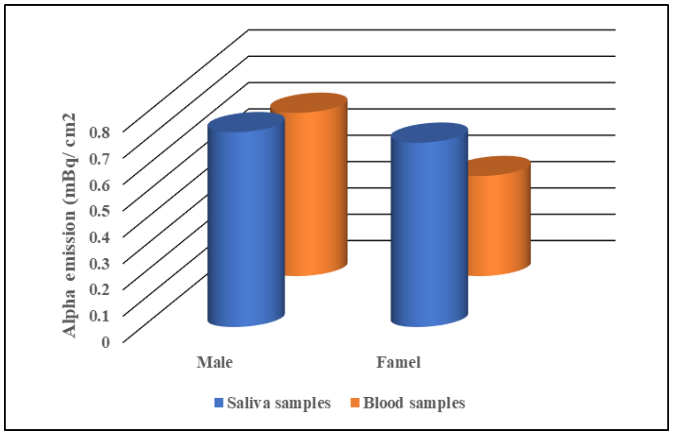

Fig. 2: The alpha emissionin in saliva and blood samples according to the gender

In order to elucidate the relationship between years of smoking and dependency of effect alpha emission, the study cohort was stratified into distinct groups. With the exception of more than forty years of smoking, the differences between alpha particle emissions in all study groups were not significant with the smoking years. This finding can be explained by the fact that the longer smoking years were exposed to cigarette pollution for a longer period of time than the shorter smoking years. While the significant association was discovered between alpha emission and years of smoking, there is a stronger significant correlation with years of smoking more than forty, as shown in Fig. 3.

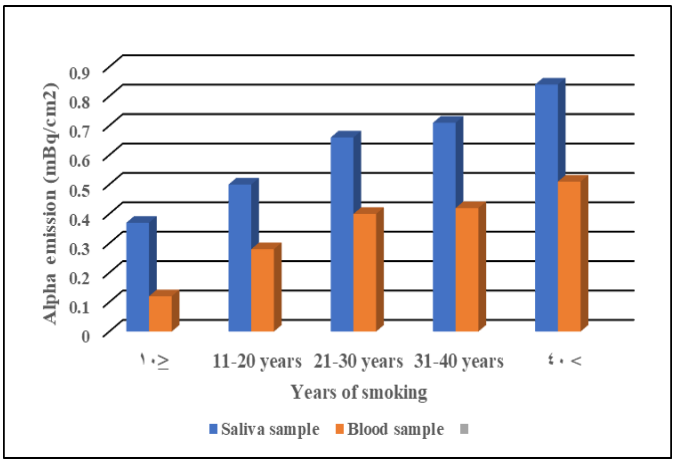

Fig. 3: The alpha emissionin in saliva and blood samples according to the years of smoking

Table 3 compares the alpha particle emission rate reported in this study for different age intervals with saliva and blood samples. Age from 18 to 44 years old was favorably and non-significantly correlated with the alpha particle emission rate in blood and saliva samples. Whereas, the correlation results confirmed a statistically significant difference between alpha particle emission rate in saliva and blood samples and age interval among 44- to 82-year-old provinces ($p < 0.05$). According to their standardized coefficients (ß), in saliva and blood samples. The stronger significant impact of alpha emission rate was seen at ß = 0.318 with age interval (70-82) in saliva samples, while the lowest was found at ß = 0.156 with age interval (44-56) in blood samples. Additionally, the highest and lowest insignificant effects were discovered at ß = 0.012 and 0.528, respectively, with age interval (31-43) in blood and saliva samples.

Table 3: Analyzing the correlation between age interval and alpha partical emission rate in blood and saliva samples using linear regression

Alpha emission rate (mBq/cm²)	Age Interval	Saliva samples			Blood samples		
		Standardized Coefficients (ß)	t-value	P- value	Standarized Coefficients(ß)	t-value	p-value
	18-30	0.072	1.219	0.225	0.093	1.857	0.157
	31-43	0.047	0.577	0.528	0.012	0.138	0.857
	44-56	0.161	2.218	0.032*	0.156	1.928	0.040*
	57-69	0.190	2.429	0.027*	0.270	3.447	0.001*
	70-82	0.318	4.212	0.000*	0.171	3.042	0.003*

There is no significant difference ($p > 0.05$) in alpha emission across all samples in the current investigation at different BMIs, according to the link between track density rate in blood and saliva samples and BMI.

Discussion

Smoker saliva and blood samples exhibited a significantly higher mean value of alpha track density compared to non-smoker samples. This result implies that radionuclides emit higher levels of alpha emitters in the blood and saliva of smokers. These findings indicated that individuals aged 70-82 years who smoke had a higher alpha track density. This conclusion can be supported by the evidence that younger smokers and non-smokers had a comparatively shorter duration of exposure to alpha emitters compared to older individuals. This outcome may be attributed to the escalating levels of radioactive isotopes resulting from the absorption of radioactive substances through ingestion and inhalation over the course of one's lifetime. Both the number of cigarettes smoked and the length of time smoked are positively connected with the risk of lung cancer. Consequently, the concentration of alpha track particles gradually builds up in saliva and blood over an extended duration. Tobacco contains trace amounts of radioactive isotopes such as 210Pb, 210Po, and 226Ra. These isotopes are released as alpha particles when cigarettes are burned.

Conclusions

The distribution of alpha particle emissions in the saliva and blood samples from smokers and non-smokers was not equal. The average alpha level in smokers' blood and saliva samples was nearly once higher than the average alpha track density in non-smokers. The alpha track density level was recorded to be decreasing in the following order: saliva samples > blood samples. The alpha track density in smoker saliva samples differed from that in non-smoker samples by 23%. While the percentage difference between the alpha track density of smoker and nonsmoker blood samples was 9%. So, the alpha particle emission was found to be decreasing in the following order: smoker > non-smoker. High levels of track density in smoker saliva and blood samples compared to that of non-smoker samples suggest that the process of active emission of alpha particles is adequately preserved because of cigarette smoking. Furthermore, the result explains that the alpha emission in saliva and blood samples was found to be proportional to the period of smoking. The statistical findings showed that a highly significant correlation between the interval age (70-82 years) and the alpha particle emission rate in both saliva and blood samples was found.

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