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The Effect of Exercising on Smokers' Lung Capacity

Sondos Majdi Taher, Marit van Silfhout, Asiya Nazir*

Department of Applied Science and Mathematics, College of Arts and Sciences, Abu Dhabi University - P.O Box 59911, United Arab Emirates

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ABSTRACT

The purpose of this research paper is to investigate whether exercising can reduce the harmful effects caused by smoking. Additionally, the hypothesis of this research study proposes that results will show that the percentage lung capacities of smokers who exercise are similar to non-smokers who don't exercise in which it will prove that exercising does, in fact, decrease the harmful effects of smoking as a smoker who exercises is almost as healthy as a non-smoker who does not exercise. Henceforth, the hypothesis of this research will be accepted. To know that, a questionnaire was prepared, which assisted in placing the individuals in one of 4 groups. The sample size included 152 participants aged 18 and above from the Emirate of Abu Dhabi. A spirometer was used to find the real lung capacity of the participants. The estimated vital capacity was calculated by substituting the height and weight of a person into an equation that gives the body surface area, and then the answer is either multiplied by 2,500 or by 2,000 to find the estimated lung capacity for males or females respectively. After collecting the essential data, it was found that people who smoke and exercise have higher lung capacity than those who smoke but don't exercise. The t-test was used, and it was found that the difference is significant between those two sets of data. The results imply that exercising could, in fact, reduce the harmful effects of smoking as it has been predicted in the hypothesis. However, in order to be completely free of the risks of smoking, it is highly recommended to quit smoking as well fully.

*Corresponding Author

Name: Asiya Nazir
Phone: 0097125015447
Email: asiya.nazir@adu.ac.ae

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INTRODUCTION

For approximately 1.1 billion people, smoking has become a daily habit (WHO, 2018). Unfortunately, this is a bad habit because it has many negative health effects. Messages about those health effects are often ignored, or people cannot do anything about it since smoking is highly addictive. Every year, more than 7 million people are killed as a result of tobacco smoke. Not even direct smokers, but also second-hand smokers suffer a lot. The tobacco epidemic is one of the biggest public health threats the world has ever faced. The purpose of this study is to find concrete evidence from which recommendations can be proposed to the public for ways to increase their vital capacity to have healthier bodies and live a longer and healthier life. Smoking and exercising both target the same organs; however, the opposite effects. Exercising can lead to an increase in the vital capacity by 5% up to 15%, (Damon *et al.*, 2007). Smoking harms the body while exercising benefits the body; consequently, the question that needs answering is, "Does exer-

cising decrease the harmful effects of smoking?" Dr. Stanton Glantz, professor of medicine in the division of cardiology at the University of California, San Francisco, stated that exercise improves cardiovascular function and cholesterol levels and that exercising, in general, is good for everyone. "So if you smoke and exercise, you're going to be better off than if you smoke and don't exercise, (Stein, 2008)." Yet, the question that lies here is, to what extent can exercise eliminate the risks of smoking-related diseases?

MATERIALS AND METHODS

For this experiment, the participants were asked to answer a questionnaire with questions related to their smoking and exercise routines (Appendix A). This questionnaire aided in placing the participant in the right group. To be exact, the participants were separated into 4 groups of smokers who exercise, smokers who do not exercise, non-smokers who exercise, and non-smokers who do not exercise. The sample size included 148 individuals aged 18 and above from the Emirate of Abu Dhabi. The estimated vital capacity, the real vital capacity, and then the vital percentage capacity of each person in the sample was found. First, the mass and height of the people were measured. Then, the estimated vital capacity was found by substituting the height and weight of each person into an equation that gives the body surface area: BSA (m^2) = (Height (cm) x Weight (kg) / 3600)$^{\frac{1}{2}}$. After that, the body surface area was either multiplied by 2,500 to find the estimated lung capacity for males or multiplied by 2,000 to find the estimated lung capacity for females. After finding the estimated lung capacity, the real lung capacity was found using a spirometer.

A spirometer is a medical device that is used to measure a persons' exhale capacity of air in liters. Through the spirometer test, the lung function of the participants was identified, whether it is at a healthy level or not. Before starting the test, each participant was asked to sit in a chair, and a clip was placed on their nose to make sure the nostrils are closed. After this, the participants were asked to take a deep breath in and to hold this breath for a couple of seconds, followed by exhaling into the breathing tube. This procedure was repeated 3 times to make sure the results are consistent and accurate. The values that are measured are the vital capacity (VC), which is the maximum amount of air a person can expel from the lungs after a maximum inhalation.

RESULTS AND DISCUSSION

The higher the percentage or ratio, the healthier the lungs are (Table 1). A low ratio, which is lower than 80% for adults, suggest that the airways are in an unhealthy condition, (Sampson, 2017). After the lung capacities were found, it was time to determine where the similarities and/or differences of the results are significant between the different groups. T-test, which aids in determining if the arithmetic means of two sets of data are significantly different, was used to evaluate that.

First, the lung capacities of smokers who exercise and smokers who don't exercise were evaluated whether the difference is significant or insignificant. Then, the difference between the lung capacities of smokers who exercise and non-smokers who do not exercise was also evaluated. The difference should be insignificant for the hypothesis to be accepted. If the results state otherwise, the hypothesis must be rejected.

The variance of each set of data of the two sets of data being compared must be found; consequently, the standard deviation as well. And then the t-value will be found using the following equation, (Alan *et al.*, 2007).

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$$

The value found will be compared to the t-critical value. If the t-value has a greater value than t-critical, then the difference is significant if it is smaller, the difference is insignificant.

T-critical value is found from the Table 2 below (Alan *et al.*, 2007),

Statistics show that the rate of smoking cigarettes continues to increase steadily among young people. As seen, the results were significantly different between youth smokers and youth non-smokers, suggesting that "early effects of smoking leads to problems in the respiratory system." On top, the results suggest the importance of implementing smoking cessation counseling for adolescents (Anong and Premtip, 2013). It appears that the average lung capacity percentage for smokers who exercise is almost similar in all the age groups, as illustrated in Figures 1 and 2 (which are obtained from the results in Tables 3, 4 and 5. Additionally, smokers who exercise have higher average lung capacity than smokers who don't exercise in all age groups as well as for a smoker who does not exercise it seems like the average lung capacity will keep

Table 1: Interpretation of spirometer results

VC	Result
Greater than or equal to 80% of the estimated lung capacity.	Normal
Less than 80% of the estimated lung capacity.	Abnormal

Table 2: T-critical value table

Degree of free	Significance Level					
	20%(0.20)	10%(0.10)	5% (0.05)	2 %(0.02)	1% (0.01)	0.1% (0.001)
1	3.078	6.314	12.706	31.821	63.657	636.919
2	1.886	2.92	4.303	6.965	9.925	31.598
3	1.638	2.353	3.182	4.541	8.841	12.941
4	1.533	2.132	2.776	3.747	4.604	8.61
5	1.476	2.015	2.571	3.365	4.032	6.859
6	1.44	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.405
8	1.397	1.86	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.25	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.35	1.771	2.16	2.65	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.14
15	1.341	1.753	2.131	2.602	2.947	4.075
16	1.337	1.746	2.12	2.583	2.921	4.015
17	1.333	1.74	2.11	2.567	2.898	3.965
18	1.33	1.734	2.101	2.552	2.878	3.922
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.85
21	1.323	1.721	2.08	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.5	2.807	3.767
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.06	2.485	2.787	3.725
26	1.315	1.706	2.056	2.479	2.779	3.707
27	1.314	1.703	2.052	2.473	2.771	3.69
28	1.313	1.701	2.048	2.0467	2.763	3.674
29	1.311	1.699	2.043	2.462	2.756	3.659
30	1.31	1.697	2.042	2.457	2.75	3.646
40	1.303	1.684	2.021	2.423	2.704	3.551
60	1.296	1.671	2	2.39	2.66	3.46
120	1.289	1.658	1.98	2.158	2.617	3.373
∞	1.282	1.645	1.96	2.326	2.576	3.291

getting worse as a person ages Figure 1; thus, showing the importance of exercising on lung capacity. Consequently, the gap between smokers who exercise and don't exercise in relation to lung capacity keeps getting bigger. The lung capacity percentage in the age group 18-27 is 70.60 and 69.29 respectively, so the results are almost similar suggesting due to the young age the tobacco harmful effects may still not be as bad as an older person where the harm is too much that exercising will not do as much benefit in comparison to a person who is younger in age since a younger person has a stronger body and may not be smoking as long as an older person who is a smoker. In the age group 48+ years, the lung capacity percentage for smokers who exercise is 72.79, and the lung capacity for smokers who don't exercise is 53.34.

As predicted, the results, as demonstrated in Figure 2 show very clearly that there is a noticeable difference between the vital lung capacity percentage of those who smoke and exercise and those who don't smoke nor exercise. A noticeable finding, in all age groups, smokers who exercise have lower average lung capacity percentage than non-smokers who don't exercise; henceforth, illustrating a harmful effect of smoking on the lungs.

Although the results seem to vary between smokers who exercise and smokers who don't exercise, with one age group being approximately close, and between smokers who exercise and non-smokers who don't exercise, are the similarities and differences significant? The T-test will be used. Table 6 summarizes the data required to perform the t-test for each of the groups.

Comparison between smokers who exercise and smokers who don't exercise:

1. Degrees of freedom used in the table: 25+48-2= 71
2. From Table 2, the 5% significant difference caused due to chance value is chosen.
3. T-critical value from the table is: 1.980
4. T-value, which is found by substituting the numbers into the above formula mentioned in the planning section of the essay, is equal to 2.075

T-value is greater than t-critical; therefore, the difference between the vital lung capacity percentages is indeed significantly different between smokers who exercise and smokers who don't exercise.

Comparison between smokers who exercise and non-smokers who don't exercise:

1. Degrees of freedom used in the table: 26+48-2= 72
2. From Table 2, the 5% significant difference caused due to chance value is chosen.
3. T-critical value from the table is: 1.980
4. T-value, found by substituting the numbers into the formula, is: -2.202

The t-critical value is much larger than the t-value; thus, the results are very similar, and a smoker who exercises can be as healthy as a non-smoker who doesn't exercise. Henceforth, the hypothesis of this research is accepted.

For non-smokers who exercise, 29 out of 47 persons have a normal lung capacity (Table 9), the highest being 136.38% (Figure 3). This data was collected to determine the importance of exercise in increasing lung capacity.

Table 7 shows all the data collected from smokers who exercise. First, Table 7 is divided by gender; then, each group is sorted based on agefrom smallest to largest. BSA (m^2) = (Height (cm) x Weight (kg) /3600)$^{\frac{1}{2}}$, the answer is multiplied by 2000 to find estimate lung capacity for a female and by 2500 for a male. Real lung capacity is the average vital capacity after 3 trials per individual using a spirometer in order to increase accuracy. %VC = (Real VC x 100%) / Estimated VC.

Table 8 shows all the data collected from smokers who don't exercise. First, the table is divided by gender; then, each group is sorted based on age from smallest to largest

The results of non-smokers who don't exercise (Table 8 and Figure 4) and their similarity to smokers who exercise based on the t-test also emphasize the benefits of exercising proving that exercising is beneficial to the human body to the point that a smoker who exercises can be as healthy as a non-smoker who doesn't exercise, yet relatively not healthier since the average lung capacity of smokers who exercise is lower than non-smokers who don't exercise by 8.29% (Table 11). However, in general, it is possible for a smoker who exercises to be healthier than a non-smoker who exercises due to the similarities shown by the t-test and relatively small total average percentage difference. A smoker smoking lightly and exercising more frequently while taking care of his/her general health, he/she can be even healthier than a non-smoker who doesn't exercise. By asserting that working-out increases lung capacity, it is demonstrated and fully verified that exercising is the reason smokers who exercise have

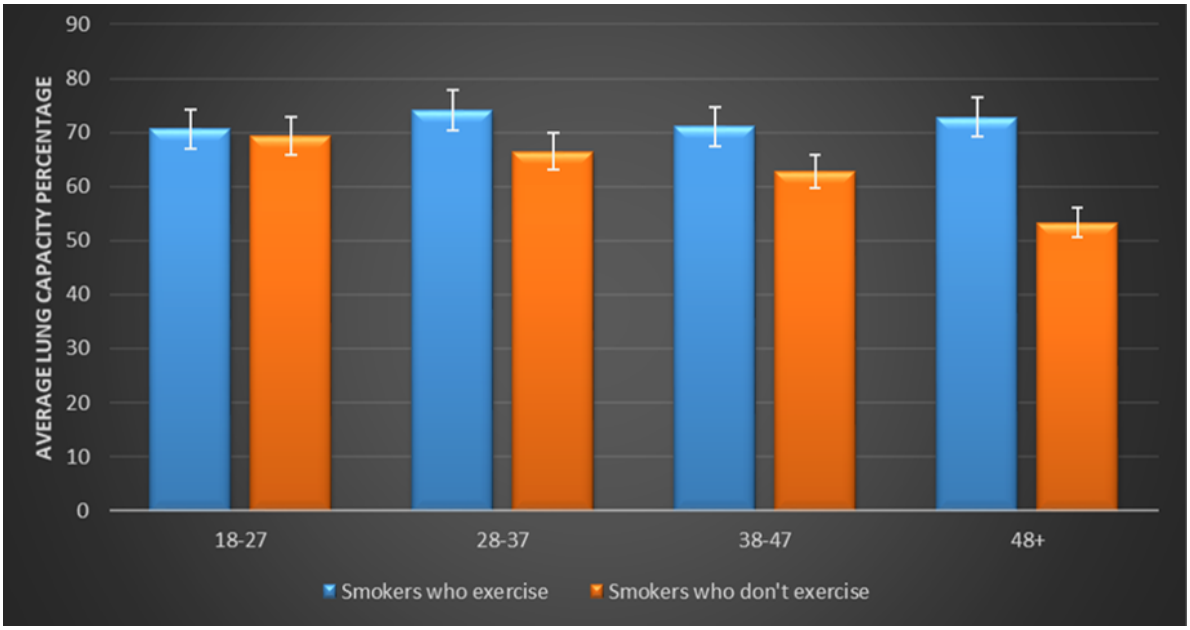

Figure 1: A bar chart presenting the average lung capacity percentage of smokers who exercise in comparison with smokers who don't exercise based on age groups. Error bars represent 5% of each value

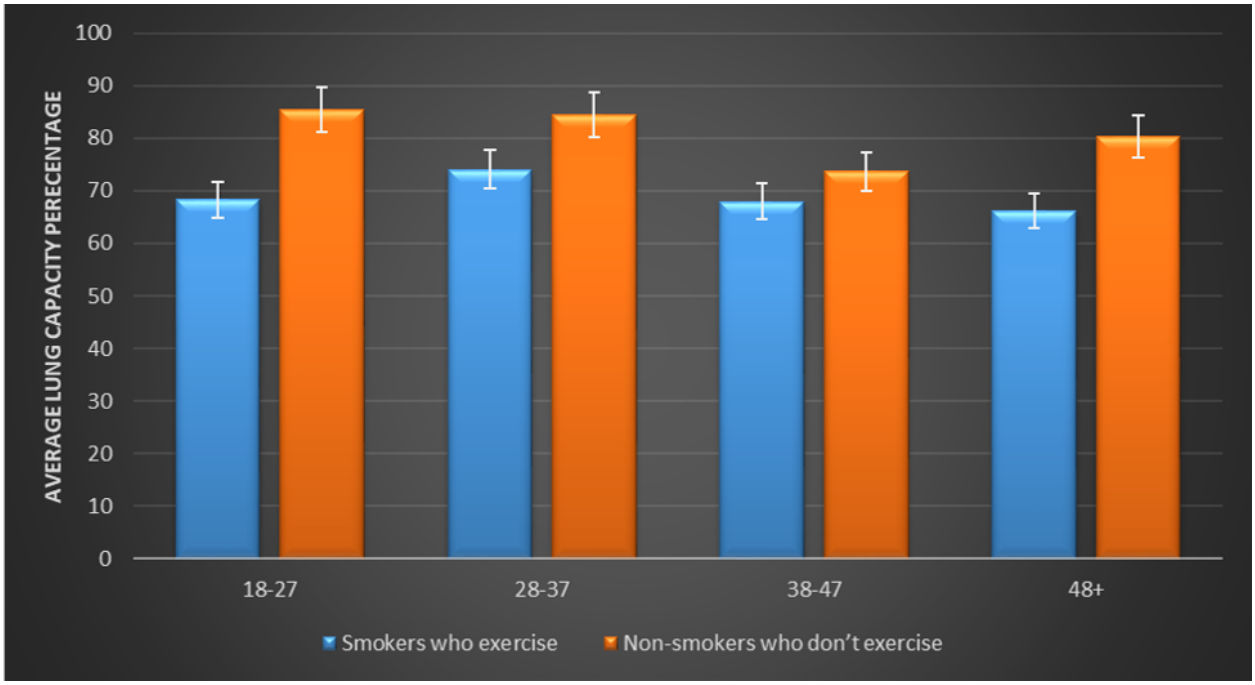

Figure 2: A bar chart presenting the average lung capacity percentage of smokers who exercise in comparison with non-smokers who don't exercise based on age groups. Error bars represent 5% of each value

Table 3: Data from smokers who exercise categorized basedon age groups

Smokers who exercise			
Age/years	VC %	Average VC%	Standard Deviation
18 - 27	66.42	70.60	±12.927
	50.90		
	72.01		
	88.30		
	79.29		
	72.69		
	58.84		
	80.39		
	92.42		
	54.79		
	87.04		
	87.71		
	59.08		
	50.59		
	75.56		
	78.38		
	54.88		
	68.93		
	71.26		
	57.94		
	81.41		
	64.32		
28 – 37	82.08	74.04	±13.135
	83.02		
	70.75		
	52.09		
	91.12		
	82.34		
	79.81		
	88.48		
	63.80		
	60.91		
	70.94		
	76.60		
	88.10		
	51.81		
	58.19		
	84.57		
38 – 47	68.41	71.07	±13.550
	71.01		
	65.24		
	54.58		
	86.06		
	92.13		
	60.08		
48+	84.87	72.79	±12.620

The average lung capacity of each group is calculated by adding all numbers of VC% and dividing by a number of samples.
The standard deviation is calculated using Microsoft Excel Sheet

Table 4: Data from smokers who don't exercise categorized based on age groups

Smokers who don't exercise			
Age/years	VC%	Average VC%	Standard Deviation
18 – 27	77.64	69.29	±12.189
	98.36		
	68.36		
	57.76		
	67.35		
	65.49		
	65.66		
	74.09		
	55.46		
	62.76		
28 – 37	69.55	66.47	±19.803
	43.34		
	54.91		
	55.45		
	99.02		
	76.57		
38 – 47	70.48	62.75	±15.531
	35.71		
	68.87		
	64.37		
	74.33		
48+	63.71	53.34	±6.921
	49.57		
	50.08		
	49.99		

The average lung capacity of each group is calculated by adding all numbers of VC% and dividing by a number of samples. The standard deviation is calculated using Microsoft Excel Sheet

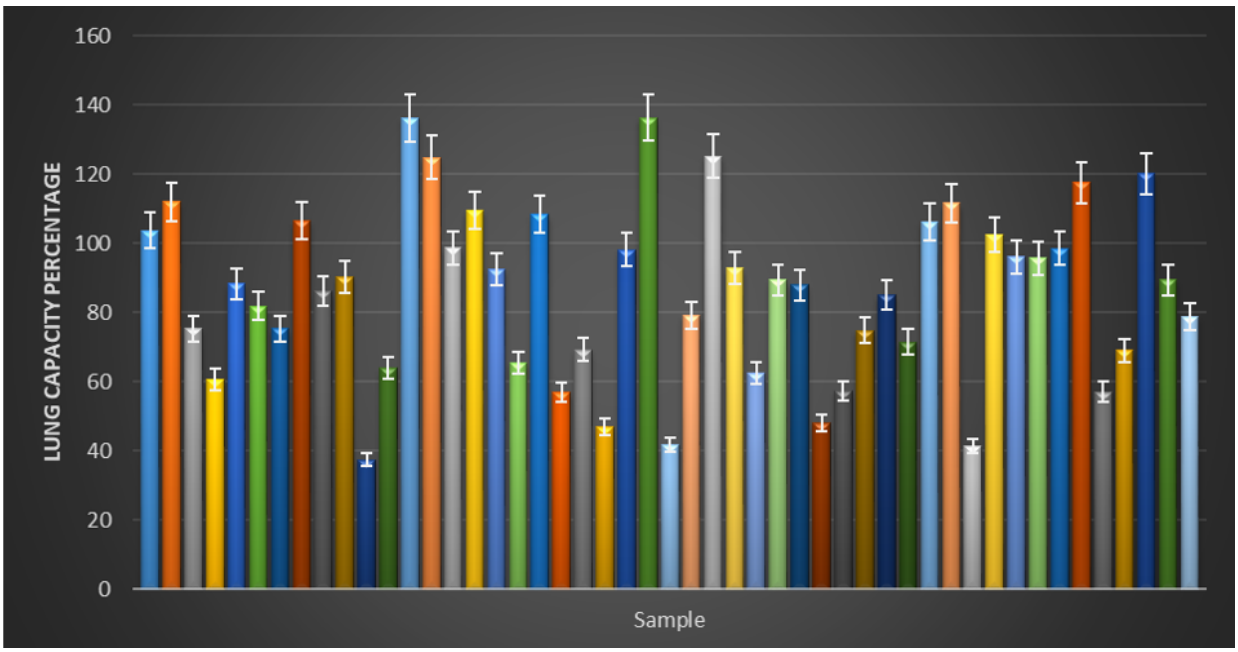

Figure 3: Comparison among lung capacity percentage of non-smoker individuals who exercise. Error bars represent 5% of each value

Table 5: Data from non-smokers who don't categorize based on age groups

Non-smokers who don't exercise			
Age	VC %	Average VC %	Standard Deviation
18-27	102.21	85.33	±18.92
	73.37		
	82.89		
	54.22		
	65.98		
	117.01		
	84.85		
	76.68		
	93.56		
	102.57		
28-37	79.78	84.38	±6.51
	88.98		
38 – 47	85.09	73.63	±11.97
	81.29		
	88.87		
	80.55		
	80.21		
	60.53		
	63.54		
	66.46		
	56.09		
48+	76.29	80.33	±22.02
	48.47		
	109.70		
	80.04		
	87.13		

The average lung capacity of each group is calculated by adding all numbers of VC% and dividing by a number of samples. The standard deviation is calculated using Microsoft Excel Sheet.

Table 6: The variance and mean of each data

	Sample	Mean	Variance
Smokers who exercise	48	71.95	162.4
Smokers who don't exercise	25	64.76	215.5
Non-smokers who don't exercise	26	80.25	281.5

a healthier lung than smokers who don't exercise. This is demonstrated by the t-test, and since 33.3% of smokers who exercise have normal lungs, which is 4 times the percentage of smokers who don't exercise and have normal lungs (Table 12).

Table 9 shows all the data collected from non-smokers who exercise. First,Table 9 the table is divided by gender. Then each group is sorted based on age from smallest to largest. BSA (m^2) = (Height (cm) xWeight (kg) / 3600)$^{\frac{1}{2}}$, the answer is multiplied by 2000 to find estimate lung capacity for a female and by 2500 for a male. Real lung capacity is the average vital capacity after 3 trials per individual using a spirometer in order to increase accuracy. %VC= (Real VC x 100%) / Estimated VC.

Table 10 shows all the data collected from non-smokers who don't exercise. Table 10 is divided by gender. Then each group is sorted based on age from smallest to largest.

For smokers who exercise (Table 12), only 16 out of 48 had a vital lung capacity of above 80%, the highest being 92.42%, as seen in Table 7 and also

Table 7: Summary of the data collected among smokers who exercise

	Smokers who exercise						
Gender	Age/years	Height/cm	Weight/kg	BSA/m^2	Estimate VC/cm^3	Real VC/cm^3	VC%
Females	18	161	55	1.568	3137	2083	66.42
	18	159	47	1.441	2882	1467	50.90
	19	165	68	1.765	3531	2567	72.69
	21	169	88	2.033	4065	3757	92.42
	21	150	43	1.339	2677	1467	54.79
	22	156	53	1.515	3031	1533	50.59
	23	156	64	1.665	3331	2517	75.56
	23	172	70	1.829	3658	2867	78.38
	24	160	85	1.944	3887	2133	54.88
	25	156	81	1.873	3747	2670	71.26
	26	167	63	1.710	3419	2783	81.41
	31	169	65	1.747	3494	3183	91.12
	31	159	55	1.559	3117	2567	82.34
	34	165	63	1.699	3399	2603	76.60
	36	157	52	1.506	3012	2653	88.10
	36	170	57	1.641	3281	1700	51.81
	37	176	72	1.876	3752	2183	58.19
	38	165	59	1.644	3289	2250	68.41
	40	159	62	1.655	3310	2350	71.01
	42	170	86	2.015	4030	2200	54.58
	46	164	69	1.773	3546	3267	92.13
	52	158	53	1.525	3050	2589	84.87
	52	158	53	1.525	3050	2252	73.83
	59	168	75	1.871	3742	2233	59.69
Males	18	178	75	1.926	4814	3467	72.01
	18	167	85	1.986	4964	4383	88.30
	18	180	65	1.803	4507	3573	79.29
	19	183	100	2.255	5637	3317	58.84
	20	182	79	1.998	4996	4017	80.39
	21	178	80	1.989	4972	4328	87.04
	21	178	80	1.989	4972	4361	87.71
	21	184	89	2.133	5332	3150	59.08
	24	184	91	2.157	5392	3717	68.93
	25	189	92	2.198	5494	3183	57.94
	26	176	81	1.990	4975	3200	64.32
	28	170	67	1.779	4447	3650	82.08
	28	161	73	1.807	4517	3750	83.02
	28	195	100	2.327	5818	4117	70.75
	29	186	96	2.227	5568	2900	52.09
	31	163	74	1.830	4576	3652	79.81
	31	194	98	2.298	5745	5083	88.48
	32	178	91	2.121	5303	3383	63.80
	33	184	92	2.168	5421	3302	60.91
	33	186	85	2.096	5239	3717	70.94
	37	176	89	2.086	5215	4410	84.57
	41	193	96	2.269	5672	3700	65.24
	43	176	84	2.026	5066	4360	86.06
	47	182	87	2.097	5243	3150	60.08

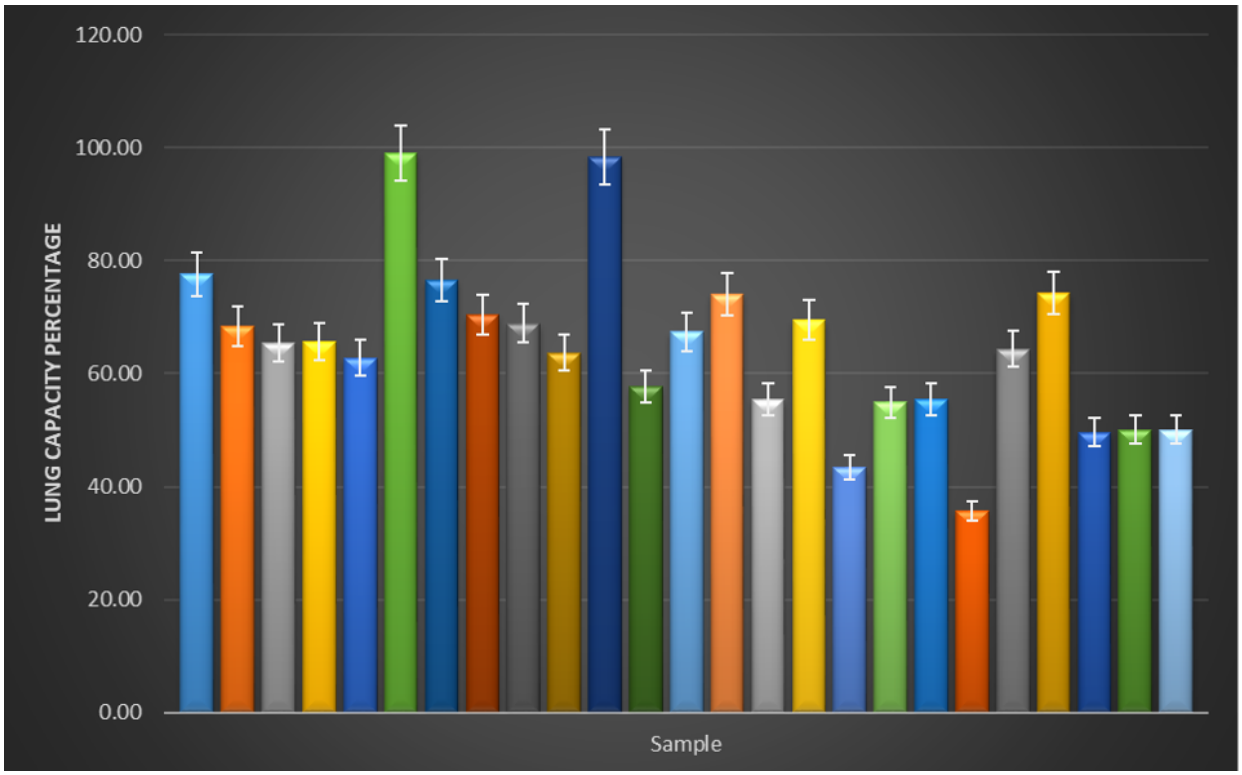

Figure 4: Comparison among lung capacity percentage of smoker individuals who don't exercise. Error bars represent 5% of each value

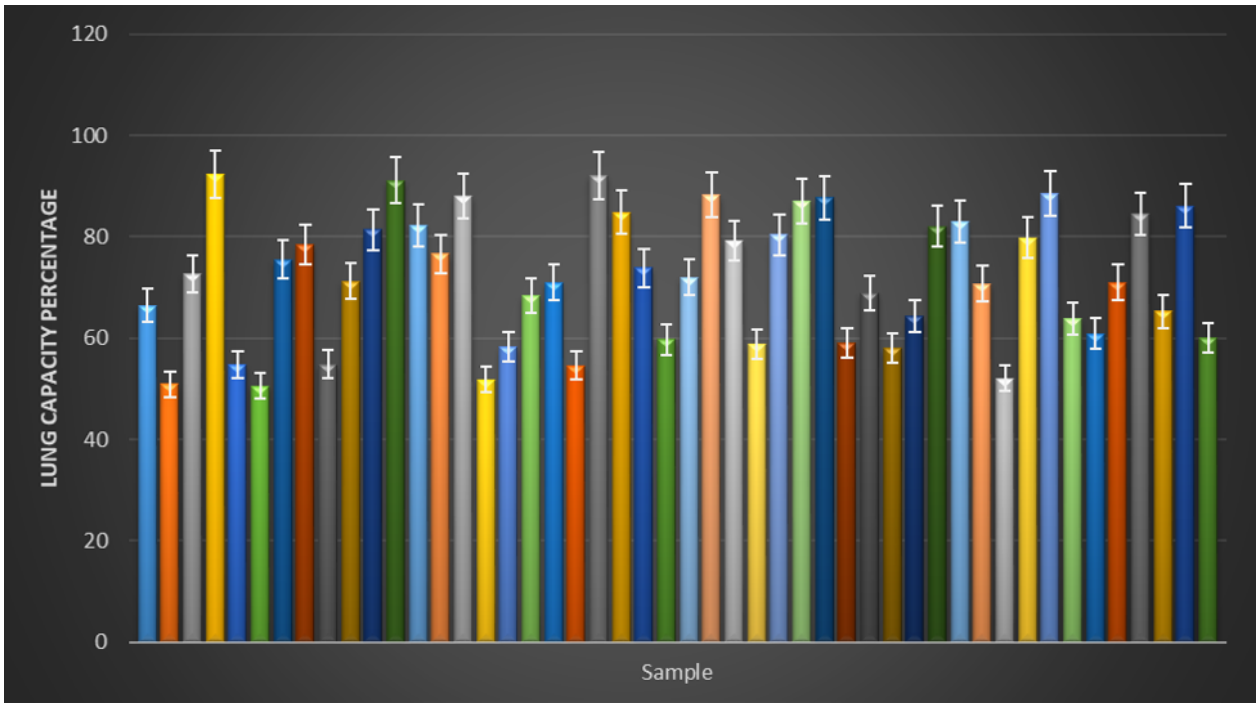

Figure 5: Comparison among lung capacity percentage of smoker individuals who exercise. Error bars represent 5% of each value

Table 8: Summary of the data collected among smokers who don't exercise

Smokers who don't exercise							
Gender	Age/years	Height/cm	Weight/kg	BSA/m^2	Estimate VC/cm^3	Real VC/cm^3	VC %
Females	18	160	53	1.535	3070	2383	77.64
	20	167	82	1.950	3901	2667	68.36
	24	161	65	1.705	3410	2233	65.49
	24	165	65	1.726	3452	2267	65.66
	27	168	73	1.846	3691	2317	62.76
	37	166	71	1.809	3619	3583	99.02
	37	159	55	1.559	3117	2387	76.57
	39	175	73	1.884	3768	2655	70.48
	43	178	76	1.938	3877	2670	68.87
	48	168	61	1.687	3374	2150	63.71
Males	18	180	71	1.884	4710	4633	98.36
	22	181	83	2.043	5107	2950	57.76
	23	169	81	1.950	4875	3283	67.35
	26	163	68	1.755	4387	3250	74.09
	26	178	75	1.926	4814	2670	55.46
	29	184	91	2.157	5392	3750	69.55
	31	186	110	2.384	5960	2583	43.34
	35	173	105	2.246	5616	3083	54.91
	36	177	105	2.272	5680	3150	55.45
	41	187	95	2.221	5554	1983	35.71
	43	167	80	1.926	4816	3100	64.37
	44	181	81	2.018	5045	3750	74.33
	48	174	95	2.143	5357	2655	49.57
	50	155	75	1.797	4492	2250	50.08
	53	172	74	1.880	4701	2350	49.99

BSA (m^2) = (Height (cm) xWeight (kg) / 3600)$^{\frac{1}{2}}$, the answer is multiplied by 2000 to find estimate lung capacity for a female and by 2500 for a male. Real lung capacity is the average vital capacity after 3 trials per individual using a spirometer in order to increase accuracy. %VC= (Real VC x 100%) / Estimated VC.

illustrated in Figure 5. While 32 out of 48 had a lung capacity percentage of bellow 80% stating unhealthy lungs, the lowest being 35.71%, which is severely abnormal. The average lung capacity of smokers who exercise is 71.95%. A percentage of less than 80 is considered to be abnormal or in other words, unhealthy lung capacity. Although the overall result for smokers who exercise indicates an unhealthy lung, 33% had a lung capacity that is equal to or above 80%. This suggests that even if exercising aids in lowering the harms resulting from smoking, or probably prevents them from progressing; it is not fully enough for a smoker to have a fully healthy lung. Even if a smoker exercises regularly, smoking will still harm his/her lungs.

For smokers who don't exercise (Table 8 and Figure 6), 23 out of 25 their lung capacity percentages were below 80%, as briefed in Table 12. The average lung capacity of smokers who exercise is higher than smokers who don't exercise by 7.15% (Table 11). Additionally, the risk of having an abnormal lung capacity being a smoker who doesn't exercise increases by 1.4 times if a person is a smoker who doesn't exercise on a weekly basis (Figure 7). This emphasizes the damaging effect of smoking and the beneficial effects of exercising. Smokers who don't exercise are more likely to suffer from lung diseases such as lung cancer and lung infections as their lung capacity will continue to decrease since the alveoli will continue to die. This indicates that without exercising, a smoker's lung will definitely be harmed. For the different age groups, the average lung capacity for smokers who don't exercise decreases as age increased, as presented in Figure 1 above. With age, more and more alveoli are damaged due to smoking. This designates that without

Table 9: Summary of the data collected among non-smokers who exercise

Non-smokers who exercise						
Age/years	Height/cm	Weight/kg	BSA/m^2	Estimate VC/cm^3	Real VC/cm^3	VC %
18	156	67	1.704	3408	3533	103.68
18	153	49	1.443	2886	3233	112.03
20	155	64	1.660	3320	2500	75.30
20	166	64	1.718	3436	2083	60.64
20	52	50	0.850	1700	1500	88.25
20	160	54	1.549	3098	2533	81.76
20	158	62	1.650	3299	2483	75.27
20	170	56	1.626	3252	3467	106.59
21	170	86	2.015	4030	3472	86.14
21	162	67	1.736	3473	3133	90.23
22	165	80.4	1.920	3839	1433	37.33
22	160	76	1.838	3676	2350	63.93
23	178	68	1.834	3667	5000	136.34
23	170	85	2.003	4007	5000	124.78
25	176	80	1.978	3955	3900	98.60
25	161	50	1.495	2991	3277	109.56
28	173	83	1.997	3994	3700	92.63
36	161	73	1.807	3614	2367	65.49
36	170	68	1.792	3584	3883	108.35
37	153	59	1.584	3167	1800	56.84
38	163	54	1.564	3127	2167	69.28
39	160	74	1.814	3627	1700	46.87
43	170	58	1.655	3310	3250	98.19
43	170	75	1.882	3764	5133	136.38
44	159	90	1.994	3987	1667	41.80
44	169	94	2.101	4201	3330	79.26
44	163	50	1.505	3009	3767	125.17
45	173	84	2.009	4018	3728	92.77
46	158	82	1.897	3794	2367	62.38
18	170	62.2	1.714	4285	3833	89.47
18	180	79	1.987	4969	4367	87.88
20	163	80	1.903	4758	2283	47.99
20	165	63	1.699	4248	2433	57.28
24	160	66	1.713	4282	3200	74.74
26	172	88	2.050	5126	4360	85.05
30	163	73	1.818	4545	3250	71.51
31	177	82	2.008	5020	5333	106.25
33	180	80	2.000	5000	5586	111.71
34	177	78	1.958	4896	2020	41.26
34	177	78	1.958	4896	5017	102.47
35	173	72	1.860	4650	4467	96.05
38	190	100	2.297	5743	5497	95.70
40	187	100	2.279	5698	5617	98.58
48	170	70	1.818	4545	5343	117.56
53	181	91	2.139	5347	3050	57.04
53	193	102	2.338	5846	4033	68.99
55	188	101	2.297	5742	6900	120.18
56	162	70	1.775	4437	3967	89.40
57	180	90	2.121	5303	4183	78.88

Table 10: Summary of the data collected among non-smokers don't exercise

Non-smokers who don't exercise							
Gender	Age/year	Height/cm	Weight/kg	BSA/m^2	Estimate VC/cm^3	Real VC/cm^3	VC %
Females	19	165	60	1.658	3317	2433	73.37
	19	175	110	2.312	4625	3833	82.89
	19	169	62	1.706	3412	1850	54.22
	21	161	48	1.465	2930	1933	65.98
	21	170	65	1.752	3504	4100	117.01
	22	163	58	1.621	3241	2750	84.85
	24	169	71	1.826	3651	2800	76.68
	25	163	56	1.592	3185	3267	102.57
	29	158	77	1.838	3677	2933	79.78
	42	172	80	1.955	3910	2367	60.53
	46	156	54	1.530	3059	2033	66.46
	51	152	70	1.719	3438	1667	48.47
	53	175	65	1.778	3555	3900	109.70
Males	18	163	53	1.549	3098	3167	102.21
	24	155	54	1.525	3812	3567	93.56
	33	165	62	1.686	4214	3750	88.98
	38	180	108	2.324	5809	4943	85.09
	39	187	90	2.162	5405	4394	81.29
	40	173	81	1.973	4932	4383	88.87
	40	168	73	1.846	4614	3717	80.55
	41	182	95	2.192	5479	4394	80.21
	45	176	83	2.014	5036	3200	63.54
	47	173	89	2.068	5170	2900	56.09
	48	183	137	2.639	6597	5033	76.29
	53	165	78	1.891	4727	3783	80.04
	55	153	54	1.515	3787	3300	87.13

BSA (m^2)= (Height (cm) x Weight (kg) / 3600) $^{\frac{1}{2}}$, the answer is multiplied by2000 to find estimate lung capacity for a female and by 2500 for a male. Reallung capacity is the average vital capacity after 3 trials per individual usinga spirometer in order to increase accuracy. %VC= (Real VC x 100%)

Table 11: The average vital capacity percentage per group

The average vital capacity percentage per group	Smokers who don't exercise	Non-smokers who exercise	Non-smokers who don't exercise
71.95%	64.76%	86.2%	80.24%

Calculated by adding all lung capacity percentages in the group, then divided by the number of individuals in that group

exercising, smoking will continue to devour the lung as time passes.

To be more specific, Figure 8 which represents the data in Table 13, is illustrating the total percentage of smokers and non-smokers with either normal or abnormal lung capacity grouped by the frequency of exercising. This bar graph provides a more in-depth illustration because the frequency of exercising is included, which is, of course, a very important factor regarding lung capacity as well. In this graph, the smokers and non-smokers are divided into four different groups based on their amount of exercise, and thereby it is showing the total percentage in each group of how many have normal or abnormal lung capacity. Health science students from Greek participated in a study to examine smoking behavior and physical activity (PA). The analysis showed a strong inverse association between smoking and PA, as well

Table 12: Number of smokers and non-smokers with either normal lung capacity or abnormal lung capacity based on whether they exercise or not

	Total Smokers		Total Non-smokers	
	Exercise	Don't Exercise	Exercise	Don't Exercise
Normal Lung Capacity	16	2	29	15
Abnormal Lung Capacity	32	23	18	11
Total	48	25	47	26

An individual with a normal lung capacity has a percentage of lung capacity that is 80% or above. While an individual with an abnormal lung capacity has a percentage of lung capacity that is less than 80%

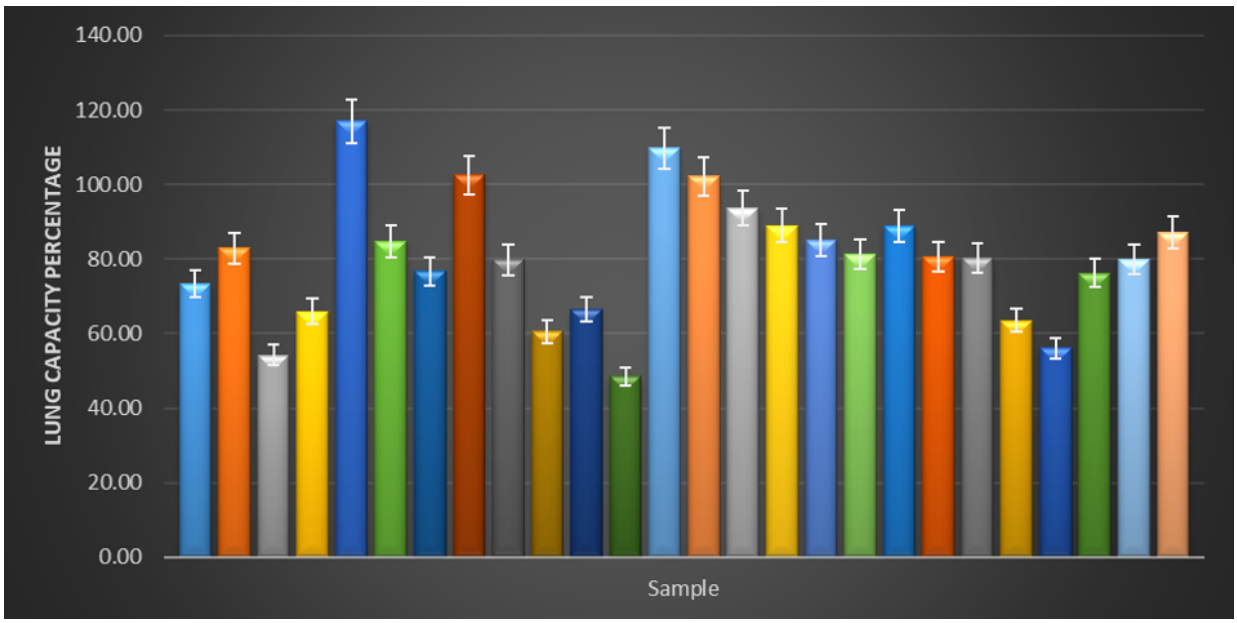

Figure 6: Comparison of lung capacity percentage of non-smoker individuals who don't exercise. Error bars represent 5% of each value

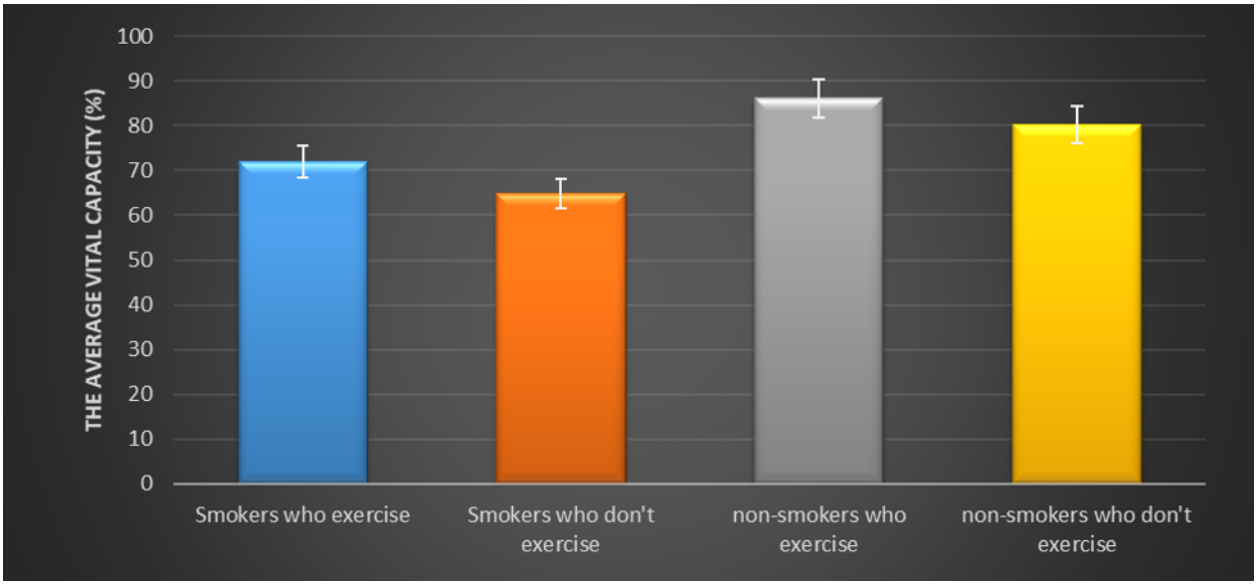

Figure 7: A bar chart presenting the average vital capacity percentage of each group. Error bars represent 5% of each value

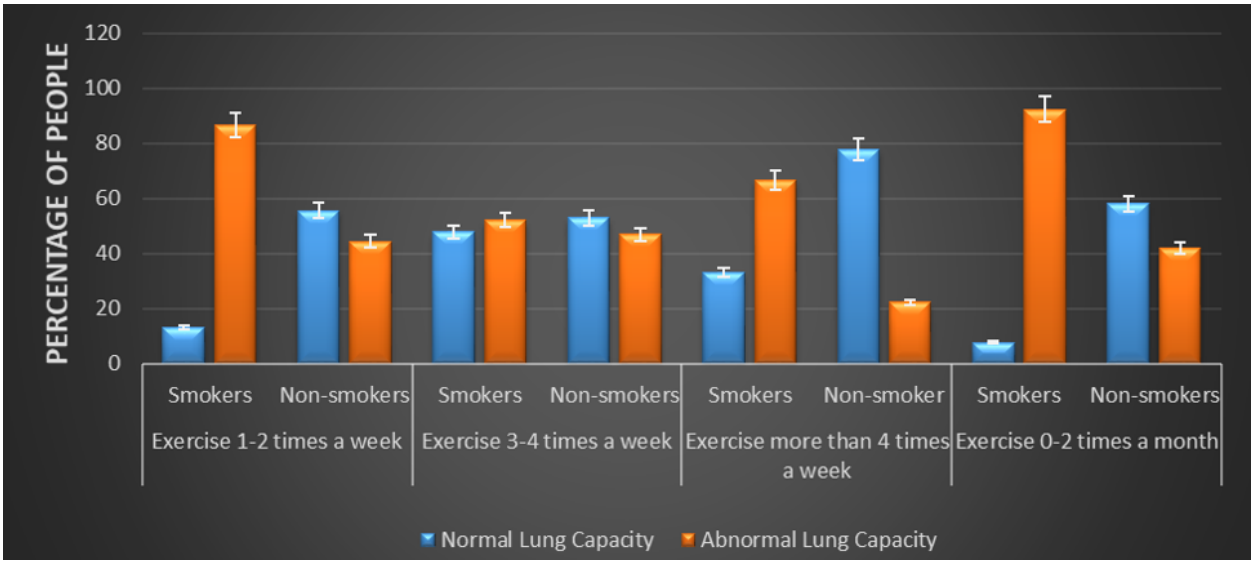

Figure 8: A bar chart illustrating the total percentage of smokers and non-smokers with either normal or abnormal lung capacity grouped by the frequency of exercising. Error bars represent 5% of each value

as that smoking, was associated with significantly decreased odds of being either moderately or highly physically active. Smoking volume was also negatively related to PA (Papathanasiou *et al.*, 2011)

If we take a closer look at the graph, we can see that in every group, the total percentage of non-smokers with healthy lung capacity is higher than the total percentage of people who smoke and exercise at the same rate. Especially in the group of individuals who exercise 0 to 2 times a month, there is a significant difference between smokers and non-smokers who have a normal lung capacity. A total of 26 individuals are smokers in this group and only 2 of them have a healthy lung capacity making a total of 8% of that group only, while there are 18 from the 31 non-smokers with a healthy lung capacity which is more than 50% of non-smokers who exercise 0-2 times a month have healthy lungs. Since this is also the group in which smokers have the highest amount of individuals with unhealthy lung capacity and the number of persons with unhealthy lung capacity within smokers is significantly decreasing as exercising frequency increases, it can be said that exercising does affect the lung capacity of smokers positively. Although the top total percentage of smokers with healthy lungs are those who exercise 3-4 times per week or more than 4 times per week, yet the results appear to reveal that in our samples the higher percentage of smokers with normal lung capacity are those who exercise 3-4 times a week rather than more frequently. This does show that exercising is very important since the percentage of smokers who exercised less is significantly lower, but also showing that other factors such as biological or lifestyle so have an influence on the lung capacity as well. A cross-sectional study has assessed pulmonary function and respiratory muscle strengths in two groups of women. One group included 28 healthy policewomen that trained 3 hours a day for a minimum of 2 years, while the other group included 31 untrained second-year healthy students. After analysis, the mean values of FVC, FEV1, PEF, MIP, and MEP were significantly higher in the police-trained group in comparison to the untrained-students group. Henceforth, exercising, especially for the long term, will improve lung function as well as respiratory muscle strength (Kamal *et al.*, 2017).

Another notable finding is that non-smokers have the highest percentage of individuals with healthy lung capacity in the group who exercise most frequently, more than 4 times a week; henceforth, stating not only that the most beneficial way to have healthier lungs is exercising more frequently but also quitting smoking. Besides, since the average lung capacity for non-smokers who exercise is 86.2% Figure 6 which is not only higher than that of smokers who exercise but also is considered healthy; thus, indicating that exercising alone will not fully illuminate the negative causes due to smoking on the lungs but smokers should consider to reduce the level of their smoking or even better to quit smoking.

Recommendation

According to the World Health Organization, the recommended physical activity duration for people aged 16-64 years are the following:

Table 13: The total percentage of smokers and non-smokers with either normal lung capacity or abnormal lung capacity grouped by the frequency of exercising

	Exercise 1-2 times a week		Exercise 3-4 times a week		Exercise more than 4 times a week		Exercise 0-2 times a month	
	Total Smokers (%)	Total Non-smokers (%)	Total Smokers (%)	Total Non-smokers (%)	Total Smokers (%)	Total Non-smokers (%)	Total Smokers (%)	Total Non-smokers (%)
Normal Lung Capacity	13	56	48	53	33	78	8	58
Abnormal Lung Capacity	87	44	52	47	67	22	92	42

An individual with a normal lung capacity has a percentage of lung capacity that is 80% or above. While an individual with an abnormal lung capacity has a percentage of lung capacity that is less than 80%

1. At least 150 minutes (2.5 hours) of moderate-aerobic activity per week or at least 75 minutes (1.25 hours) of vigorous-aerobic activity per week.
2. Aerobic physical activity should be performed in sessions of no less than 10 minutes duration.
3. Increase amount and intensity over time.
4. For additional benefits, an adult should engage in 300 minutes (5 hours) of the moderate-aerobic activity or 150 minutes (2.5 hours) of vigorous-aerobic activity throughout the week, or an equivalent moderation of both types of aerobic physical activity, (World Health Organization, 2018).

Due to the evidence stated in this research paper and WHO recommendations the overall recommendations and guidance will be discussed by the use of:

1. Transtheoretical Model: This will be applied to motivate people to exercise regularly.
2. Health Belief Model: will aid smokers in quitting smoking.

Following one or the other is beneficial, yet for optimal health benefit, it is recommended to follow both; for best life quality, a person should be smoke-free and meets the weekly physical activity recommendation by WHO.

A sedentary lifestyle is also known as “the new smoking” as it has many negative health effects. Some researches even suggest that not being active and not exercising is even worse for one’s health than smoking (Drash, 2018). Therefore, it is highly important to exercise, especially for those who do not require to move a lot during their day, since a ”sitting lifestyle” is very harmful as well as for those who smoke and are finding it difficult to stop or reduce smoking. The Transtheoretical Model aids individuals to make a change in their life or themselves; it is also known as the stages of change. Henceforth, it can be applied to quitting smoking; however, in this research paper, the model is explained in terms of physical activity.

As shown in Figure 9, the Transtheoretical Model consists of at the minimal five stages, which are pre-contemplation, contemplation, preparation, action, maintenance, and termination. Pre-contemplation is the stage where a person is in denial and, therefore, doesn’t have the intention to take any action. In this stage, awareness is required in a way even to personalize the harms of not taking action and stating the benefits of making a change; in this situation, exercising on a weekly basis. Then comes contemplation where a person is planning to take action after a specific period of time; therefore, he/she needs motivation and encouragement. The preparation is when the person is planning to start taking action; meaning the set time of taking action is near. So it is important for a public health professional or even the people around him who have enough knowledge to aid and support him/her in developing a concrete plan and setting a realistic gradual goal. Action is when the person has started. In this stage, social support is very important, as well as problem-solving and assistance.

The next part is where a person might either relapse or reach the maintenance stage then relapse, in this situation support and motivation is important, a person should recognize how much they have

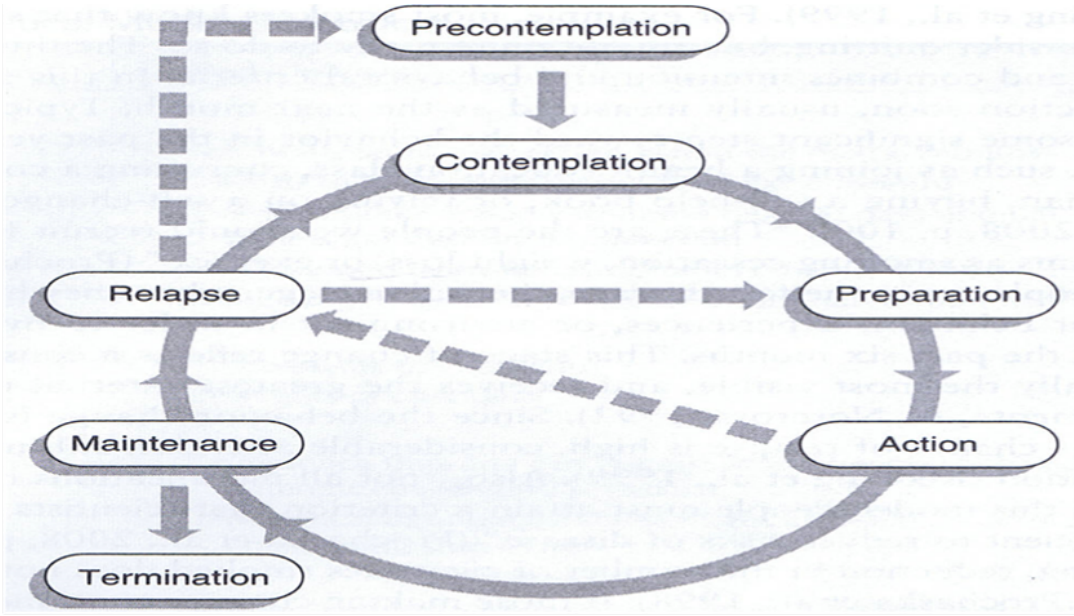

Figure 9: Transtheoretical Model consists of at the minimal five stages

achieved and as a result go back on track by starting from an appropriate stage in the model till they reach the maintenance stage and eventually termination. It is important for people to remember not to turn a bad week into a bad month. Maintenance is when the new behavior has been practiced for 6 months, so here the person has been exercising on a weekly basis as recommended for the last 6 months period. And then termination when the new intended health-promoting behavior becomes a natural habit embedded within a person's lifestyle.

As has been mentioned before, to be completely free of the risks of smoking, it is highly recommended to quit smoking fully. However, this is easier said than done, not for every smoker, it is as easy to stop smoking. It is important to understand why, for some people, it is easier than other people to change their behavior and lifestyle. The (HBM, 2018) is one of the models that can be used to understand more about smokers' beliefs and attitudes.

As shown in Figure 10, there are six different concepts in the Health Belief Model, which are perceived benefits vs. barriers, perceived threat, perceived seriousness & susceptibility, self-efficacy, and cues to action. Perceived benefits mean that a smoker should believe that quitting smoking would have more advantages and that it would really benefit his or her health. However, perceived barriers might stop some smokers from quitting since they might think there are more (psychological) costs of the advised action rather than benefits. Also, to be able to change their behavior, a smoker must be aware of how serious the condition and its consequences are (perceived seriousness), and he must realize that he or she got a high chance of developing the diseases that are caused by smoking (perceived susceptibility).

Moreover, a very important component is self-efficacy. Self-efficacy means that a smoker must be confident in his or her ability to stop smoking. Without having confidence, it is going to be very hard to change any behavior. There also should be strategies that activate a smoker's readiness to actually start taking action to quit smoking, which is defined as cues to action in the model (University of Twente). This could be done by a (public) health professional, for example, by providing information about how to get started, how to change, promote awareness, and motivate people who became smoke-free to continue on the right path and not relapse. Even if one of these factors is missing, it is already much harder to stop smoking. In that case, it is very important to seek professional help that can support and guide persons to stop smoking as well (Safila and Anam, 2015).

In short, many chronic diseases are associated with behavioral risk factors. Although these diseases are not themselves communicable, their behavioral risk factors, for instance, smoking, is readily transferable from one population to another, through international travel and modern communication. Nicotine is the main chemical in tobacco smoke. It is a stimulant drug that accelerates the transfer of messages between the brain and body, making it even more addictive than heroin. Therefore, it is important for public health practitioners to implement prevention programs and interventions for anti-smoking that can help smokers to quit smoking as well as enforce

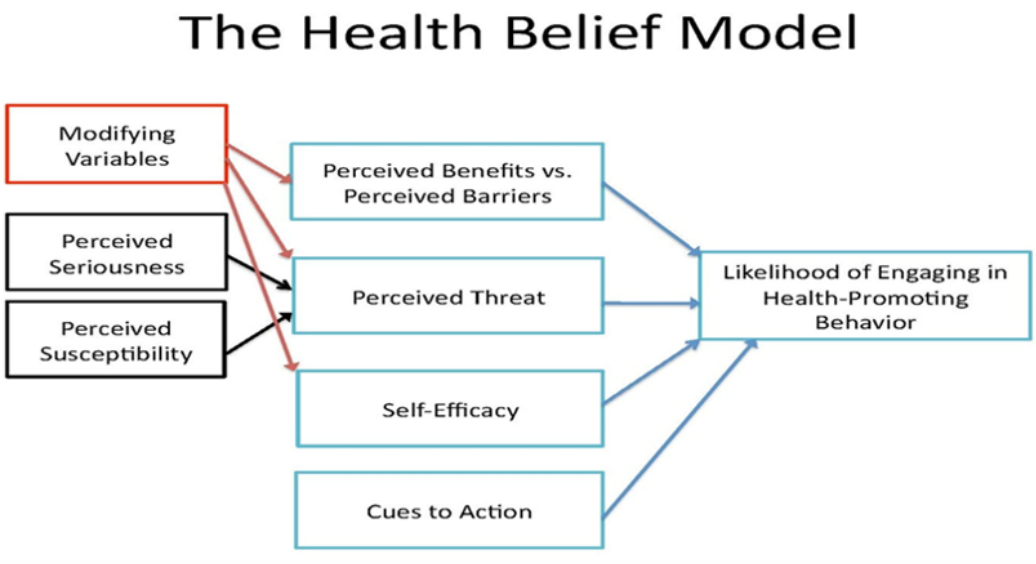

Figure 10: Different concepts in the Health Belief Model

exercising in a way that working out can become a habit for everyone in the community. This can also be done with the use of the Transtheoretical Model and/or The Health Belief Model. In that way, health experts can raise awareness of the harmful consequences that result from smoking to reduce the prevalence of smokers. Henceforth, the goal of increasing the lung capacity of individuals in addition to improving their quality of life will be accomplished.

Limitations

Uncertainties were not mentioned as they not only do not fall under the uncertainty of the apparatus used, but the equation needed to find the body surface area contains multiplication, meaning that the uncertainty would have to be converted into a percentage of each number, and so the uncertainty would differ for each value. The apparatus's uncertainty would not be useful if used as they are not of the main concern when finding the body surface area and small differences such as ± 0.5 would not make a notable difference in the estimated lung capacity, the main uncertainties and limitations lie within measuring the lung capacity using a spirometer because some people were not using it properly, regardless of illustrating the right way of using a spirometer and guiding them to the proper way in order to get accurate measures, yet to minimize inaccuracy 3 readings were obtained from each individual and the average was taken in order to get the most accurate results possible.

Numerous factors other than smoking and exercise can affect the vital lung capacity, for instance, the type of diet the person is following, the metabolism of the individual at the time of the experiment, how long the person has been smoking, how heavily they smoke, and their general health. Certain diseases such as asthma lead to a decreased lung capacity. The level of exercise plays a major role as smokers may not exercise as heavily as they smoke, and thus exercising will not be enough to compensate for or recover the lung tissue damage that results from smoking. If the individual has been smoking for a long time but only started exercising recently, exercising will not counterweigh the harmful effect of smoking even if that individual exercises heavily because sometimes the damage of alveoli is irreversible, and is known as Emphysema. Also, a person who has an unhealthy weight and inactive lifestyle will form adipose tissue around the rib cage and abdomen, causing a decrease in the functional residual capacity, which is the volume of the air left in the lungs after exhaling. As well as non-smokers being exposed to second-hand smoke does have an effect on the lungs. Another factor that requires further investigation is the type of exercise the person is performing, whether it is light, moderate, or vigorous, which could ultimately distinguish if these factors influence the benefits of exercise in smokers. For that reason, the results can't be 100% reliable.

Finally, the reasons mentioned above led to the decision to have a 5% error bar in representing the graph. When the t-test is used, scientists tend to want to be at least 95% sure of their results, and for that reason, the largest possible uncertainty of 5% has been chosen to represent all the limitations and uncertainties of our collected and processed data. The trend in the results can be clearly seen, and the effect of smoking and exercising can be concluded from the obtained.

APPENDIX A: Questionnaire

Does exercising reduce the harmful effects of smoking?

Note: Please answer all the following questions

1. Gender: Female / Male
2. Age:
3. Height (cm):
4. Weight (kg):
5. Do you smoke?

(a) Yes

(b) No

6. Do you play sports or exercise?

(a) Yes

(b) No

7. How often do you play sports/exercise?

(a) 1-2 times a week

(b) 3-4 times a week

(c) More than 4 times a week

(d) 0-2 times a month

CONCLUSION

In conclusion, smoking leads to the destruction of alveoli due to the toxic chemicals released into the body when the tobacco smoke is inhaled, and with time, the destruction only continues leading to lower and lower lung capacity. When people are continuously exposed to the tobacco smoke, the harmful effects of smoking will continue to damage their lungs, but with regular exercise that corresponds to the amount of smoking, lung function may be maintained. Smoking has long-term effects on the body. Not only does it harm the lungs, but it also harms the pulmonary system and slows the transport of oxygen throughout the body as the chemicals found in tobacco smoke bind to the red blood cells instead of oxygen. This will eventually not allow smokers from being able to exercise as heavily, and they will slowly begin to lose their fitness and the ability to exercise. Exercising will become painful and exhausting due to the slow transport of oxygen in the blood. With a lower oxygen concentration, the cells will begin anaerobic respiration and produce lactic acid into the muscles. This will cause shortness of breath during exercise and muscle strains. On top of this, from the results obtained it seems that exercising maintains the lung function of smokers, and if a smoker reduces the amount of smoking or quits as well as increased frequency of exercise while eating healthy and taking good care of his/her body, it is possible to increase lung capacity to healthy levels and reduce the regression of any present diseases at the same time prevent diseases that could otherwise appear due to practicing unhealthy behavior. The significant difference between smoker and non-smoker on breathing time the p-value < .005 with df=2".

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A study like this is not possible without the participants – thank you for taking the time to complete the questionnaire and perform the spirometer test. Your participation is greatly appreciated.

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