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Revital Nassimov.

The acute pulmonary effects of waterpipe smoking.

Supervisor: Prof. Kestutis Malakauskas MD, PhD.
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3. Summary

Revital Nassimov. The Acute Pulmonary Effects of Water-Pipe (Hookah) Smoking.

Background: Water-pipe form of tobacco smoking that has increased its prevalence among young adults in the last several years. It may have been partially due to misconception among smokers that water pipe smoking (WPS) is safer than cigarette smoking (CS).

The aim is to evaluate the acute pulmonary effects of water-pipe smoking in a non smoking young adult population.

Objectives: We will establish the values of PFT (pulmonary function tests) by spirometry, pH of EBC (exhaled breath condensate) and exhaled CO levels of the study subjects at baseline and immediately after WPS or CS. We will compare the baseline values with CS, with the water-pipe smoking and between the 2 methods of smoking.

Design of study: Eight non smokers Lithuanian University of Health Science (LUHS) students volunteered and completed our study. All were evaluated at baseline by spirometry for PFT, exhaled pH levels by EBC and exhaled CO levels. The students than were randomized to smoke either a cigarette or the tobacco via WPS. One hour later the same tests were repeated and recorded. The students were asked to repeat the process after three days at which time they were asked to smoke the via different method from their initial method of smoking, and all tests were repeated and recorded as previously described.

Results: For the pH levels of the EBC, WPS significantly increased the pH compared to the baseline values (P=0.008); also there was a significantly increase at the exhaled CO values of the WPS compared to the baseline values (P=0.001).

Conclusions: Our study demonstrate that WPS has higher CO exposure levels and a higher increase in pH levels compared to CS. There arent acute pulmonary changes after WPS.

Thus the acute effects of WPS on lungs are more hazardous than CS.

Recommendations: This study adds and confirms the previously published literature, and further supports the recommendations for increased public awareness of the hazardous acute pulmonary effects of WPS.
4. Acknowledgements

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5. Conflict of interest

The author reports no conflicts of interest.
6. Ethics Committee Clearance

Lietuvos Sveikatos Mokslų Universitetas
Bioetikos Centras

Dėl pritarimo tyrimui

LSMU Bioetikos centras, įvertinęs (MA) vientisų studijų programos – MEDICINA
VI k. stud. Revital Nassimov (mokslinio darbo vadovas: prof. Kęstutis Malakauskas, LSMUL
KK Pulmonologijos ir imunologijos klinika) mokslinio-tiriamojo darbo temos: „The acute
pulmonary effects of water pipe smoking“ tiriamojo darbo anotacija, kuri leidžia spresti, jog
planuojame tyrimo neturėtų būti pažeistos tiriamojo teisės, todėl šiam tyrimui pritariama.

Bioetikos centro vadovo pavaduotojas

doc. E. Peičius
7. Abbreviations list

Hospital of Lithuanian University of Health Sciences (HLUHS)
Lithuanian University of Health Sciences (LUHS)
World Health Organization (WHO)
Eastren Meditarrenian Region (EMR)
Waterpipe Smoking (WPS)
Waterpipe (WP)
Cigarette Smoking (CS)
Carbon Monoxide (CO)
Carboxyhemoglobin (COHb)
Parts Per Million (PPM)
Respiratory Symptoms (RS)
Respiratory Rate (RR)
Cigarette Smoking Deep Inspiration (S-DI)
Cigarette Smoking Normal Inspiration (S-NI)
Pulmonary Function Tests (PFT)
Exhaled Breath Condensate (EBC)
Forced Vital Capacity (FVC)
Forced Expiratory Volume in 1 second (FEV₁)
Maximal Expiratory Flow at 50% of Vital Flow Capacity (MEF 50% of VFC)
Forced Expiratory Flow (FEF 25-75%)
8. Terms

- Spirometry: the most common of the pulmonary function tests (PFTs), measuring lung function, specifically the amount (volume) and/or speed (flow) of air that can be inhaled and exhaled.
- FVC: the determination of the vital capacity from a maximally forced expiratory effort.
- FEV₁: Volume that has been exhaled at the end of the first second of forced expiration.
- MEF50%: Maximum expiratory flow when 50% of the FVC has been exhaled (FEF 50%) or 50% of the FVC remain to be exhaled.
- FEV1/VC: a calculated ratio used in the diagnosis of obstructive and restrictive lung disease. It represents the proportion of a person's vital capacity that they are able to expire in the first second of forced expiration.
- EBC: the exhalate from breath, that has been condensed, typically via cooling using a collection device (commonly to 4°C or subzero temperatures using a refrigerating device). EBC reflects changes in the respiratory fluid that lines the airways and is an inexpensive, non-invasive tool that has potential for scientific research, screening or diagnosing diseases of the lung and other conditions.
WPS has been practiced extensively for 400 years. Water-pipe is known by a number of different names, including nargila, argileh, goza, hookah, hubble bubble and shisha [1]. It includes a head or tobacco bowl (in which tobacco is placed), a body, a water bowl, a hose and a mouthpiece. Charcoal is placed on top of the tobacco-filled head, often separated from the tobacco by a perforated aluminum foil sheet. The smoker inhales through the hose, drawing air into and around the charcoal. The resulting heated air, which also contains charcoal combustion products, then passes through the tobacco, which, as it is heated, produces the mainstream smoke aerosol [2].

According to an advisory note of WHO on 2015 and other researches, even though cigarette smoking is the dominant form of tobacco use in most parts of the world, waterpipe use accounts for a significant and growing share of tobacco use globally [4]. It is most prevalent in Asia, Africa and the Middle East, but it is a rapidly emerging problem on other continents [6] [7]. A more concerning fact is the increase prevalence among young people and children globally at the last several years [1] [5] [6] [8]. Since 2005, the first advisory note of WHO about WPS has been published, much research has been conducted on both the health hazards [11] [12] and the increasing prevalence of waterpipe smoking in many countries and populations [4] [6] [7]. In spite of the increase in knowledge, there is still a prevailing public misconception that waterpipe tobacco smoking is somehow protective or “safer” than cigarette smoking [9] [10].

All the studies that were conducted on health hazards of the WPS on the lungs, specifically were studying the acute effects of the WPS on water-pipe smokers subjects. The studies have showed several hazardous effects and pulmonary changes due to WPS [13] [14] [15] [16] [17] [22]. Other studies compared the acute effects of WPS to cigarette smoking on smoking subjects, found a higher direct toxicant exposure and puff volume in WPS but no difference between the two methods at the pulmonary function test [18] [19] [20] [21].

The aim of this study is to evaluate several immediate acute pulmonary effects of water-pipe smoking in non smoking young adults.
10. Aim and objectives of the thesis

It has become more popular over the last decade and increased its prevalence in partially due to a misconception that water-pipe smoking is less detrimental to health than other methods of smoking especially cigarette smoking due to the flavoring tobacco and the WPS is playing a strong social role especially in young population [9]. Despite extensive studies WPS on health during past decades there is not enough literature on the acute effects of WPS on lungs in nonsmokers compared to cigarette smokers.

Aim of thesis: To evaluate several immediate acute pulmonary effects of water-pipe smoking in non smoking young adults.

In this research we have measured the values of PFT by spirometry, pH levels by EBC and CO levels by using breath CO meter, at baseline and after smoking, in a cohort of students, volunteers from LUHS.

Objectives:

1. To evaluate baseline values of lung function, pH of EBC and CO levels in exhaled air of the study subjects.
2. To assess the changes of lung function by spirometry after smoking water-pipe or cigarette.
3. To measure pH values in EBC after water-pipe or cigarette smoking.
4. To estimate CO levels in exhaled air after smoking water-pipe or cigarette.
11. Literature Review

Methodology

For the literature review there were entered in the most popular databases: http://www.nature.com/index.html, http://www.biomedcentral.com/, http://journals.bmj.com/, https://www.ncbi.nlm.nih.gov/pubmed/, and http://onlinelibrary.wiley.com/; In the search engine it was searched "waterpipe", "acute pulmonary effects" and "smoking" I sorted them according to the publication date and I chose the most relevant for my case.

Background and history of water pipe smoking

WPS has been practiced extensively for 400 years. Waterpipe is known by a number of different names, including nargila, argileh, goza, hookah, hubble bubble and shisha [1]. Its origin is often traced to India, according to one historical data, a water-pipe was invented by a physician during the reign of Emperor Akbar (ruled from 1556-1605) as a less harmful device and method of smoking tabacco, “smoke should be first passed through a small receptable of water so that it would be rendered harmless” [2], although there are theories that it was first used in South Africa, Persia, Ethiopia, or other countries.

Water pipe structure and its smoking

There are different types of water pipes. The most typical one is composed from a head, metal body, glass water bowel and a flexibale hose with a mouth piece. The tabacco is placed inside the head and is usually covered by a perforated aluminium foil. On top of the covered head a lit coal is placed. The body of the water pipe is connected to the neck of the water bowel which is filled half way water. The hose is attached to an aperture in the side of the pipe.

The tobacco used in WPS typically weighs 10 to 20 g and has 3 main forms. one of them is “Muessel” or “maasel“ (literally, “honeyed”) it contains 30% tobacco and 70% honey or molasses (treacle). “Muessel” is usually flavored with apple, mango,banana, strawberry, orange, grape, mint, cappuccino,or other additives [1]. As the smoker inhales, the tobacco smoke is sucked downward into the bowel and then bubbles up through the water into the air of the smoke chamber, and then through the hose to the smoker. The water cools the smoke and filters out a very small amount of tars and particles and about 5% of the nicotine [3].
Epidemiology and the Increase prevalence of water pipe use

Globally the highest rates of smoking occur in the african region (primarily North Africa), the eastern mediterranean Region and South-East Asia Region [2]. Over the past decade, WPS has dramatically become the most widespread tobacco use method among youth in the Eastern Mediterranean Region (EMR). The use of WPS at this region was declining through most of the 20th century. However, starting in the 1990s waterpipe smoking reemerged as a trendy habit among youth in the EMR, and quickly all over the world [4].

On a systematic review by Akl, the prevalence of current waterpipe smoking among adults was the following: Pakistan (6%), Arabic Gulf region (4%-12%), Australia (11% in Arab speaking adults), Syria (9%-12%), and Lebanon (15%) [6].

The National Adult Tabacco Survey in 2009-2010 reported a national prevalence of WPS ever use was 9.8% and 1.5% for current use. WPS ever use was more prevalent among male (13.4%), 18–24 years old (28.4%) compared to older adults. The states with the highest prevalence included Washington (17.3%), Nevada (15.8%), and California (15.5%) [7].

A more concerning fact is the increase prevalence of WPS among college and school students.

In the Middle East, 43%-61.1% of the college students reported lifetime WPS and 5.6%-43.3% reported past-month or current use [8]. In Israel, where there is a merging of Jewish and Arab cultures, WPS has recently become a common and growing phenomenon among Jewish youth. A national survey of approximately 6000 middle and high school students found that 37.7% had ever smoked WP, higher rates among Jewish (39.5%) than among Arab (30.5%) students. A different survey of 388 Jewish middle and high school students reported that 41% smoked WP, and 22% smoked at least every weekend. The rates of the WPS were 3 times higher than cigarette smoking and raised from 15% (7th grade) to 58% (9th grade) [1].

A systematic review by Akl. reported about the highest prevalence of current WPS among school students across countries: the United States, especially among Arab Americans (12%-15%) the Arabic Gulf region (9%-16%), Estonia (21%), and Lebanon (25%). Similarly, the prevalence of current waterpipe smoking among university students was high in the Arabic Gulf region (6%), the United Kingdom (8%), the United States (10%), Syria (15%), Lebanon (28%), and Pakistan (33%) [6].

On 2013, on a large university campus in the southeastern United States conducted a research with a total of 1203 participants. The participants completed a survey that assessed the use of tobacco products. The survey assessed ever use, past year use and current use of WPS and cigarette smoking. The results showed that both ever use (46.4% vs. 42.1%) and past year use (28.4% vs 19.6%) of WPS exceed cigarette use and the current use is similar between both of
the methods. Also there were no sex difference between the ever use, past year use and current use of WPS [5].

Social Attitude, Knowledge and Beliefs about WTS

According to the WHO advisory note about WPS 2015, despite the increase in knowledge, there was still a prevailing public misconception that waterpipe tobacco smoking is somehow protective or “safer” than cigarette smoking. In some countries, the prevalence of waterpipe tobacco smoking has increased in certain subgroups to exceed that of cigarette smoking.

A qualitative analysis performed in London among 32 universities students, knowledge, belief and attitude toward WPS was explored. It was mentioned by the smokers that the WPS had a very strong social role; “we go on shisha crawls instead of pub crawls; we’ll just go down Edgware Road and go to every shisha joint that’s what we enjoy doing”. Some smokers noticed and indicated some health effects, however many didn’t complain about any changes. Dual smokers believe that cigarette smoking is harmful and worse compare to WPS. The knowledge varied, some knew about the chemicals in WPS and others had very little idea. There was a broad awareness about the varying degree of health risks that the coal posses but details were not known [9].

The aim of another qualitative study was to understand the appeal to students of this form of smoking when other forms of smoking are becoming less common. Canadian and English students were interviewed and mentioned that Middle Eastern culture was a dominant feature of the context in which they started WPS. They explained the act of smoking as a social activity whilst chatting or watching television. Whatever the setting is, the waterpipe was a focal point enhancing the social atmosphere. There is a belief that due to the passage of the smoke through the water it is more healthy; “It feels light in the throat, not harsh but smooth so I can do a long drag; it means its not hurting my lungs as much or damaging it”. The students did not consider the health risks that the WPS can cause and thought its safe because there are no health warning like on cigarette. WPS is more appealing form of smoking than others due its novellity, social role and the flavouring tabacco [10].

Health effects of WPS

While WPS is being used for centuries, there is a misconception about the hazardous effects it might have on health. Moreover, this method of smoking is not being explored and researched as much as cigarette smoking health outcomes. The evidence although being limited is showing a significant association of WPS with acute cardio-pulmonary effects, long term pulmonary and
extrapulmonary consequences like gastric and oesophageal cancer, low birth weight, periodontal diseases, osteoporosis and mental health problems [11] [12].

**Acute Pulmonary Effects of WPS**

As mentioned above there was an increase in waterpipe smoking among college students [6] [8] and with that an increase of waterpipe bars around college campuses. A study was evaluating the change of exhaled CO and estimated levels of COHb of 166 waterpipe bar patrons, before entering and after leaving 6 waterpipe bars in Tempa, Florida. Mean CO increased from 6.5 Parts Per Million (ppm) to 58.2 ppm (a 795% relative boost) also significant factors of CO change were frequency of waterpipe use, number of charcoals, number of tobacco bowls, and time spent in the bar [13].

56 waterpipe smokers males, abstained from WPS at least 24 hours and than smoked waterpipe for mean of 33.1 minutes. The mean duration of WPS is 8.5 years and mean number of weekly WPS episodes was 7.8. Expired-air CO was measured and have increased significantly from a mean of 4.0 before smoking to 35.5 after smoking [14].

In a doubleblind, placebo-control study of 37 occasional waterpipe tobacco smokers [15], who were smoking 2–5 monthly smoking episodes for ≥6 months, smoked equally waterpipe tabacco and waterpipe tabacco free. In a smoking session of 45 minutes blood and expired air CO was measured before and after the session. The results showed a significant increase in exhale CO in both, placebo 3.9 before to 27.7 ppm after and for the tabacco 3.8 before to 27.9 ppm, with no difference with the condition.

In another study of 16 waterpipe smokers, The subject’s mean age was 22.9 years and smoked for an average of 4.1 years. The subjects smoked a waterpipe for 30 to 60 minutes. An Expired CO and blood samples were collected at 15, 30, 45, 60, and 90 minutes, and at 2, 3, 4, 6, 8, 12, 16 and 24 hours after the time of initiating smoking. The results showed the expired CO boost averaged 33.5 ppm, and the mean carboxyhemoglobin (COHb) boost was 6.2% [16].

In a pilot study, The acute pulmonary effects of WPS on lung function and excersice capacity were measured among 24 healthy water-pipe smokers males, mean age of 20.4 years, duration of smoking on average is 3.7 years and smoking sessions per week is 4. The subjects abstained from WPS for >48h before a waterpipe smoking session of 30-45 minutes took place. Pre-exposure (pre-WPS) and post-exposure (post-WPS) spirometry was performed and cardiopulmonary exercise testing.

The respiratory parameters had a significant decrease of Forced Expiratory Flow of 25-75% (FEF25-75%) (L) of Forced Viatl Capacity (FVC) (from 5.51 to 5.29), baseline respiratory rate
(RR) increased (from 17.7 breath/min to 19.7), the cardiopulmonary exercise results showed a significant decrease in oxygen consumption (from 1.86 liters/min to 1.7), also a decrease at the average exercise time and work performed (from 9.4 min and 138.6 Watts to 9.2 min and 136.3 Watts) and a significant increase at the expired CO levels (from 3.7 to 24.4 ppm) [17]. In another study that measured the PFT after one a single session of 30 min of WPS, there was a decrease of FEF between 25%-75% of FVC, peak expiratory flow rate. Moreover there was an increase in RR and COHb levels after the smoking session [22].

**Acute pulmonary effects, Direct comparison between WTS and cigarette**

Several studies have been done to estimate the direct toxicant exposure between WPS and cigarette smoking. On 2010 the first controlled, a crossover study was done the purpose is to measure the direct laboratory comparison of the toxicant exposure found in cigarette and WPS. 31 subjects, mean years of age is 21.4, mean monthly waterpipe use 5.2 and mean weekly cigarette smoking 9.9 cigarettes/day. Each subject smoked a 45 minutes session of WPS or a single cigarette. Expired air CO, HbCO and puff topography was measured before and after. On average CO increased, by 23.9 ppm for waterpipe and 2.7 ppm for cigarette, peak waterpipe COHb levels were three times those observed for the cigarette smoking and mean total puff volume was 48.6 liters for waterpipe as compared to 1.0 liters for cigarette [18].

On the same matter, a systematic review and meta-analysis was done on 2016 in the U.S.A. The purpose of the study was to inform public health policy and educational programming. The measurement of smoke volume in liters, and nicotine, tar, and CO in milligrams was obtained. The results showed that one WPS session was associated with 74.1 liters of smoke inhalation and one cigarette smoking was associated with 0.6 liters of smoke also one WPS session was associated with higher levels of nicotine, tar, and CO [19].

In the middle eastern countries, WPS is a major form of tabacco smoking. A study was done at the school of medicine in Teheran, Iran. PFT and respiratory symptoms (RS) were compared between WPS, smoking-deep inspiration (S-DI), smoking-normal inspiration (S-NI) and non-smokers. 673 subjects were devided to the 4 sub-groups mentioned above. RS were: whizzing, cough, sputum production and chest tightness. All the RS except the sputum production were significantly higher among all the smokers compared to the non smokers. The prevalence of wheezing and chest tightness was significantly higher among S-DI than among WP smokers and S-NI. The severity of most RS in WP smokers and S-DI, but only the severity of wheeze in S-NI, was greater than that in non-smokers. All PFT values were significantly lower in WP smokers and S-DI than in non-smokers. In addition, most PFT values were significantly lower in WP
smokers and S-DI than in S-NI, yet there was no difference between the WP smoking and the S-DI smoking [20].

A systematic review and two separate meta-analyses were conducted comparing water-pipe smokers with nonsmokers, and water-pipe smokers with cigarette smokers for each of three spirometric measurements Forced Expiratory Volume in first second (FEV1), FVC, and FEV1/FVC. Compared with no smoking, WPS was associated with a statistically significant reduction in FEV1, a trend toward lower FVC and lower FEV1/FVC. Comparing WPS with CS, there was no statistically significant difference in FEV1, FVC, and FEV1/FVC [21].

**Conclusions:**

There is an increase in prevalence of WPS, in some countries even more than cigarette smoking [5]. The WPS used to be more associated with the EMR and Asian cultures [4] [6] but now a days there is a widespread use of WPS all over the world [6] [7]. The significant increase of prevalence among college and school students is alarming [1] [5] [6] [8]. We can understand that WPS plays a strong social role, and according to the WHO there is still a prevailing misconception that WPS is “safer” than cigarette smoking despite the increase in knowledge in the matter. WPS has effects on the health such as acute cardiopulmonary effects, long term pulmonary effects and extrapulmonary effects. Studies about the acute pulmonary effects of WPS showed a significant increase of exhaled CO and HbCO, decrease values of PFT by spirometry, decrease excersize capacity, decrease in oxygen consumption and increase in RR from baseline values in young water-pipe smokers [14] [15] [16] [17]. In studies that compare the acute pulmonary effects of WPS to CS, we notice a significant increase in expired air CO levels, HbCO levels, tar and nicotine levels in WPS. Moreover in a 30-60 minutes session of WPS the mean total puff volume is significantly higher than one CS [18] [19]. We also noticed that there is no significant difference in lung function values between subjects who smoke water-pipe and those who inspire deeply when smoking a cigarette [20] and in a systematic review we can notice that there is no signifficant change of the PFT between WPS and CS [21].
12. Research methodology and methods

The study protocol was approved by the Ethics Committee of LUHS. All volunteered subjects were consented before participating in the study.

The study was conducted in the Department of Pulmonology and Immunology, at the Hospital of Lithuanina University of Health Science (HLUHS) and at the student hostel university, Kaunas, Lithuania, from November 2015 to December 2015.

The criteria for selecting the participants were: young adults (mean: 25.25 years old, SD: 2.6) and a nonsmoker subjects. The criterion for a non smoker person was a person who does not smoke every day any method of tobacco smoking and or previous smoker who quit smoking for more than five years.

For this study, 8 LUHS students, who met the above mentioned criteria, had volunteered to our study to smoke. Their PFT by spirometry, pH levels of EBC and exhale air CO levels were evaluated and recorded at baseline, i.e., before smoking and the group proceeded to smoke the method of “poison”, either waterpipe or a cigarette randomly, by a coin flip (tales WPS, heads cigarette). All previously mentioned tests were repeated one hour after smoking and the values were recorded. This process was repeated after 3 days, where the students were asked to smoke the second method from their initial method of smoking, and once again the values were recorded one hour after completion of smoking.

All the students smoked the same brand of cigarette (LD), the same brand of water-pipe tobacco (Muessel) and the same quantity of tobacco, 10 g. The same numbers of inhalation was inhaled in both methods: 12 inhalations each.

The cohort of 8 nonsmoker students consisted of 7 females and 1 male.

1. Methods:
   a. Lung Function Test (spirometry)

To assess Lung Function in subjects’ spirometry was performed. The following lung function parameters were evaluated: FVC, FVC%, FEV₁, FEV₁%, Maximum Expiratory Flow at 50% of Vital Flow Capacity (MEF 50% VFC) and MEF 50% VFC%.
The participants were instructed to inhale to the maximum and exhale completely as fast as possible and make sure to get all the air out of the lungs. A new disposable sterile mouth piece was used for each participant to prevent any cross infection. The test was performed with the subjects in sitting position with a nose clip.

b. pH of EBC

To measure the respiratory pH, EBC was performed. The measurement was done in a comfortable sitting position. EBC was collected during tidal breathing for exactly 15 minutes while sitting comfortably. The subjects breathed through a mouthpiece. The condensate was sampled in a plastic container. During the collection period a temperature of -15 to -20 C was maintained by the condenser. After each EBC collection, the pH of every sample was measured immediately using a pH-meter with a glass electrode. The range was 0.00 to 14.00

c. Exhaled air CO

Expired air CO level in ppm was measured using carbon monoxide breath monitor. It is quick and easy to use, cheap, and noninvasive. Prior the examination, each subject held their breath for 15 seconds, following it the subjects were instructed to breath slowly and fully into the tube for as long as they can.

2. Statistical Analysis

The data were written down into the computer and analyzed by using the Statistical Package for Social Sciences (SPSS for Windows) with the Fridman’s two-way analysis of variance by Ranks test. This test was used because the number of the subjects were 8. The level of significance was assumed at p < 0.05
13. Results

Table 1. Comparison between baseline, cigarette and water pipe.

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<tr>
<th></th>
<th>Baseline Mean (Sd)</th>
<th>Cigarette Mean (Sd)</th>
<th>Water pipe Mean (Sd)</th>
<th>p value</th>
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<tr>
<td>CO</td>
<td>0.38 (0.74)</td>
<td>1.88 (1.13)</td>
<td>6.13 (2.42)</td>
<td>0.001 * Baseline vs. WPS</td>
</tr>
<tr>
<td>pH</td>
<td>6.44 (0.22)</td>
<td>6.53 (0.3)</td>
<td>6.83 (0.27)</td>
<td>0.008 * Baseline vs. WPS</td>
</tr>
<tr>
<td>FEV&lt;sub&gt;1&lt;/sub&gt;</td>
<td>3.32(0.77)</td>
<td>3.27 (0.78)</td>
<td>3.23 (0.58)</td>
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<td>FEV&lt;sub&gt;1&lt;/sub&gt;%</td>
<td>95.75 (10.17)</td>
<td>91.75 (13.52)</td>
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<td>FVC</td>
<td>3.68 (0.9)</td>
<td>3.71 (0.81)</td>
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<td>FVC%</td>
<td>92 (10.7)</td>
<td>90.13 (12.52)</td>
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<td>NS</td>
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<tr>
<td>MEF50% of VFC</td>
<td>4.65 (1.4)</td>
<td>4.51 (1.58)</td>
<td>4.31 (1.31)</td>
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<td>MEF50% of VFC%</td>
<td>97.75 (21.82)</td>
<td>93.13 (27.72)</td>
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Table 2. Demographic characteristics

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<td>Female</td>
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<tr>
<td>Total</td>
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<tr>
<td>Age, years (SD)</td>
<td>25.1 (2.41)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI, Kg/m2 (SD)</td>
<td>22.23 (2.42)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

The cohort of 8 nonsmoker students consisted of 7 females and 1 male.

Statistical analysis

The data were written down into the computer and analyzed by using the SPSS for Windows with the Fridman’s two-way analysis of variance by Ranks test. This test was used because the number of the subjects were 8. The level of significance was assumed at p < 0.05

Exhaled air CO

For exhaled air CO, there was a significantly increase from mean baseline values (0.38± 0.74) and after mean WPS session(6.13± 2.42) (P=0.001) (table 1). There was a trend toward increase relative to the mean baseline values (0.38± 0.74) after mean cigarette smoking (1.88± 1.13) ( table 1).
pH levels of EBC
Comparative to the mean baseline pH values (6.44± 0.22) there was a significantly increase of pH levels after the WPS session (6.83± 0.27) (P=0.008) (table 1). There was a trend toward increase of values after the cigarette smoking session (6.53± 0.3) compare to the baseline values.

PFT
No significant change in the evaluated parameters comparing between baseline to CS, baseline to WPS and between CS to WPS.
14. Discussion of the results

1. Main findings:

Tobacco smoking is a global public health risk causing more than 6 million deaths each year; approximately one person dies every six seconds due to tobacco [9]. However, another old form that is regaining popularity is waterpipe. Although waterpipe tobacco smoking had reportedly become associated with elderly men in the Middle East, in the 1990s, it quickly surged to become an epidemic among young people. The increasing prevalence of waterpipe use outside regions in which it is traditionally known is reflected in the growth of the international waterpipe industry. As burning charcoal is usually used as the heat source in waterpipes, the smoke contains toxicants emitted from both the charcoal and the tobacco product, including flavorings. Thus, the composition of both the charcoal and the tobacco can influence the toxicant content of the smoke [2]. In the present study, we determined the acute effects of WPS on PFT, pH levels by EBC and CO levels compared to CS on non smoking young adults, LUHS students. We found an increase in exhale air CO levels and an increase in pH levels by EBC after WPS compared to baseline levels of the nonsmoking subjects. We didn’t find any significant change in lung function parameters.

2. Exhaled air of CO

In the present study our results showed a significantly increase of mean expired air CO levels after WPS compared to baseline level {mean CO WPS 6.13 (2.42) vs. baseline 0.38(0.74) p< 0.05} (table 2). There was also an increasing trend of CO levels comparing between the baseline levels and after CS {baseline 0.38 (0.74) vs. CS 1.88 (1.13)}, and between CS and WPS {CS 1.88 (1.13) vs. WPS 6.13 (2.42)} (table 1). As reported in previous studies waterpipe smokers absorbed substantially high CO levels after WPS or exposure i.e. before entering and after leaving 6 water-pipe bars (Mean CO increased from 6.5 ppm to 58.2 ppm) [13], after single session of WPS of 30-60 minutes from mean of 4.0 ppm to 35.5 ppm after the session [14] [16]. In addition the exposure to the CO is more than cigarette smokers [18] [19], presumably due to its generation by the burning charcoal placed on top of the tobacco product [15].

3. pH levels by EBC

In the present study, after comparing between 2 samples, a significant increase of pH levels after WPS compared to baseline levels was seen {mean pH WPS 6.83 (0.27) vs. baseline 6.44 (0.22), p<0.05} (table 3). There was also a trend toward increase after the cigarette smoking compared to
baseline levels \{baseline 6.44 (0.22) vs. cigarette 6.53 (0.3)\} and also a trend toward increase comparing CS and WPS pH levels \{CS 6.53 (0.3) vs. WPS 6.83 (0.27)\} (table 1). There were no studies that examine the pH levels after WPS by EBC. The one study that evaluated the acute pulmonary effects of WPS by EBC measured 8-isoprostane and nitrotyrosine levels. The 8-isoprostane levels decreased after 30 min of WPS, while nitrotyrosine levels remained unchanged [22].

4. Lung Function Test (spirometry)

For this study we evaluated several parameters: FEV$_1$, FEV$_1\%$, FVC, FVC\%, MEV50\% of VFC, MEV50\% of VFC\% (table 1). In the present study we didn't find any significant difference comparing the baseline values with WPS or CS. Lung function test is more ideally for chronic conditions like restrictive and obstructive diseases and less for acute pulmonary changes.

A pilot study [17] measured the acute pulmonary effects of WPS on lung function and exercise capacity. Post WPS a significant decrease of FEF25-75\% (L) of FVC have been found (from 5.51 to 5.29), they have concluded that acute exposure to WPS cause impairment in lung function and reduce exercise capacity in young healthy smokers. In another study that measured the acute effects after single session of WPS 30-60 minutes, found a decrease of FEF between 25\%-75\% of FVC [22]. In a systematic review and 2 meta-analyses PFT were compared between nonsmokers with WPS and WPS with CS for each of this parameters (FEV$_1$, FVC, and FEV$_1$/FVC). Compared with no smoking, WPS was associated with a statistically significant reduction in FEV$_1$, a trend toward lower FVC and lower FEV$_1$/FVC. Comparing WPS with cigarette smoking, there was no statistically significant difference in FEV$_1$, FVC, and FEV$_1$/FVC [21]. Comparing this study to previous studies, there is no change in PFT.

5. What this study adds

The present study was one of the first studies to investigate acute pulmonary effect of waterpipe smoking on lung function tests, exhale air CO levels and pH levels by EBC in non smoking young adults. This study showed that the acute effects of WPS in non smokers are more harmful than cigarette smoking.
15. Conclusions

1. In the present study there was an increase in CO levels after WPS from baseline values.
2. There was an increase in pH levels of EBC after WPS from baseline values.
3. There were no changes regarding lung function.
4. WPS causes more severe acute pulmonary effects than CS.
16. Practical recommendations

This study adds and confirms the previously published literature, and further supports the recommendations for increased public awareness of the hazardous acute pulmonary effects of WPS.

To increase the awareness about the health outcomes of WPS among school and college students.

To publish warning of harmful and hazardous outcomes of WPS on the selling products (i.e. tobacco)

To continue the research among the young populations of WPS on acute lung functions.

More studies should be done to analyze the possible relationship between WPS and pulmonary effects on non-smoking subjects.
17. Literature list


