Original Article

Effect of Chronic Water-Pipe/Shisha Smoking on Lung Function Tests Compared to Cigarette Smoking Among Sudanese Adult Males Living in Khartoum State

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Abstract

Background: Shisha/Water-pipe (WP) smoke contains large quantities of flavored nicotine, and fine and ultrafine particulate matter. These components are well known to be hazardous to the lungs and can affect the pulmonary function. Tobacco smoking researches and control efforts have generally been focused on traditional cigarettes, while little research exists on WP smoking.

Objectives: This study was designed to assess the effects of chronic WP smoking compared to cigarette smoking on pulmonary function tests (PFTs) in Sudanese adult males.

Participants and Methods: A cross-sectional study was performed on 100 adult males aging 30 - 60 years. They were comprised of 40 WP smokers, 40 cigarette smokers, and, 20 WP and cigarette smokers. PFTs [forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), the peak expiratory flow rate (PEFR), and, FEV1/FVC ratio), were measured by the electronic spirometer that consider the participant's height. The data was compared with published reference normal values for Sudanese corrected for age, sex and height.

Results: All of the measured PFTs in cigarette and WP smokers were lower than the expected normal values. The mean FEV1/FVC ratio of cigarette smokers group was 88 ± 3.7, for WP group was 87 ± 4.0 and for smokers of both cigarette and WP was 82 ± 3.2. The latter was significantly lower than the other two groups ($P < 0.005$).

Conclusions: WP smoking has a greater deleterious effect than cigarettes smoking on PFTs particularly when combined with cigarette smoking. More measures should be instituted to combat shisha tobacco smoking, as it is more damaging along with its known potential to transmit diseases due to its reuse and group use.

Key Words: Water-pipe smoking, Tobacco smoking, Pulmonary function tests, Sudan.

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Introduction

Shisha/Water-pipe (WP) smoking is known by various names, including WP and hookah smoking[(1)]. WP smoking originated in India, South Africa, Persia, and Ethiopia and is a common practice in Arab countries including Sudan[(2)]. Although started as a cheaper alternative to cigarettes among poor classes, WP smoking became frequent among the youth, high income and urban population. It has steadily been spreading among the various age groups, but especially among adolescents around the world, and gained more popularity in the Middle East in the form of shisha cafe culture[(3)].

Shisha smoke contains large quantities of flavored nicotine, fine and ultrafine

particulate matter, carbon monoxide, polycyclic aromatic hydrocarbons, volatile aldehydes, phenolic compounds and heavy metals including arsenic and lead[4-9]. Shisha smokers use tobacco flavored with apple, coconut, mango, mint, strawberry and cola, which makes the act of smoking more attractive, sweet and aromatic than cigarette smoking. The most common types of tobacco used in the shisha smoking are: Maassel, Ajami, Tumbak and Jurak[10].

The nicotine content of WP tobacco smoke is 2 - 4% and carbon monoxide concentration is 0.34 - 1.40%. Shisha smoking sessions usually last for 20 - 80 min[11]. The smokers are thus exposed to much more smoke over a longer period of time. The smoker takes 50 - 200 puffs and inhales 0.15 - 1.0 L of smoke in one session of Shisha which is equivalent to smoking of about 100 cigarettes[10,11]. The pulmonary function tests (PFTs); Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 sec (FEV1), Forced Expiratory Flow (FEF) and FEV1/FVC Ratio, are essential for the diagnosis of obstructive and restrictive respiratory illness[12]. A cross-sectional study conducted in Saudi Arabia on shisha smokers showed a significant decline in the lung function parameters of the smokers (namely, FEV1, FEV1/FVC Ratio, FEF-25%, FEF-50%, FEF-75% and FEF-75-85%) in shisha smokers compared to their age, height, weight and ethnicity matched non-shisha smoker subjects[13]. Al-Fayez, et al studied the effect of shisha and cigarette smoking on pulmonary function of Saudi males and females in the age group of 20 – 49 years. They concluded that, shisha smoking and cigarette smoking produced similar harmful effects on PFTs and increased the risk of developing obstructive airway disease, with shisha smokers being at a greater risk[14]. On the contrary, a study conducted in Izmir, Turkey investigated WP smoking habit with regard to the duration and amount of smoking and compared the results with those of cigarette smokers and non-smokers. The results showed that FEV1, FEV1/FVC parameters were higher in WP smokers compared to cigarette smokers. They suggested that the detrimental effects of WP smoking on pulmonary functions were not as great as cigarette smoking, especially on the parameters for small airways[15]. Boskabady et al conducted a study in Mashhad, Iran to investigate the effect of WP smoking on respiratory symptoms and PFTs. They reported significantly lower PFTs for WP smokers compared to non-smokers[16]. Water pipe smoking was found to deteriorate the pulmonary function and increase the oxidative stress[17].

Cigarette smoking with its negative effects has been studied extensively[18]. Merghani et al conducted a study in Khartoum, Sudan to study the relationship between regular second-hand smoke exposure at home and indictors of lung function in healthy schoolboys. Such regular second-hand smoke exposure caused significant reduction in FVC and FEV1 by about 7 - 8%[19]. A cross-sectional study was conducted in Chulalongkorn University, Thailand to study the effects of smoking on chest expansion, lung functions and respiratory muscle strength of young adults. Chest expansion and FVC of the control non-smokers was significantly greater than those of smokers[20]. A USA study conducted by Kuperman et al showed that with increasing cigarette exposure there was a progressive reduction in mean flow rates and an increase in the incidence of severe airway obstruction. Nevertheless, a significant number of heavy smokers remained within normal limits, suggesting a highly variable individual susceptibility to the effects of cigarette smoking. This implies that other genetic and environmental factors are also operative in the production of airway obstruction[21]. Another cross-sectional study was conducted in Spain, assessing the independent association of smoking with respiratory symptoms and alteration of lung function in young adults. There was a significant deterioration of FEV1 and the FEV1/FVC ratio. The risk increases with increasing number of cigarettes smoked per day[22]. A population-based cohort study was conducted in Copenhagen, Denmark to assess the effect of exercise on pulmonary functions of smokers. Moderate to high levels of regular physical activity are associated

with significant halt of lung function decline among smokers compared with low physical activity group[23].

There is a believe that WP smoking is less serious than cigarette smoking on human health[24]. This study was designed to investigate the effect of WP/shisha smoking on PFTs among male adult Sudanese chronic WP smokers and comparing the results with those of cigarette smokers and with the reported normal values[24,25]. The major PFTs parameters we used is FEV1/FVC ratio since reduction in FEV1/FVC ratio is a more specific indicator of airways disease than is the reduction in FEV1 alone in the general population[25].

Participants and Methods

An analytical cross-sectional community-based study was conducted on healthy Sudanese male adult WP and/or cigarette smokers, Khartoum, Sudan. Participants aged 30-60 years and were smoking for ≥5 years. A total of 100 adult males were included; 40 WP smokers, 40 cigarette smokers, and, 20 WP and cigarette smokers. The access for female data on the subject is not easy and is socially unacceptable. These groups were selected using convenience non-probability sampling. Places known with shisha smoking were selected, i.e., Nile Street, Aldana Café and some other places. Subjects with any lung disease (obstructive and restrictive lung disease), any co-morbidities that affect lung functions, i.e., heart failure, subjects working in any industry which generates dust or fumes and were subjected to confounding variables that affect the pulmonary function tests (like specific jobs or training, i.e., policemen and swimmers) were excluded.

An informed written consent was obtained from all participants after fully explaining to them the project. Ethical approval of this study was obtained from Department of Research's Committee, Faculty of Medicine, National Ribat University (Approval# NRU-MED-DRC-11492020). An interview questionnaire was filled by all volunteers to obtain relevant data that included age, address, occupation, duration of shisha smoking, number of shisha smoking per week, duration of the smoking session, cigarette smoking, number of cigarette smoked per day, medical history, and, drug use.

The height was measured by a standardized scale and PFTs (FEV1, FVC, FEV1/FVC ratio and PEFR) were measured by the electronic spirometer (pocket micro-spirometer, VIASYS Healthcare GmbH, D-97204 Hoechberg, Germany)[26]. The subject was asked to inspire air maximally and then to expire forcefully and as quickly as possible into the mouth piece of the spirometer and the test was repeated three times. The best of the three reproducible test results was recorded and was compared to the reference Sudanese spirometric values[24].

The data was analyzed using SPSS Software, version 25. One-sample t-test was used for the comparison with the reference values of pulmonary function tests. Correlations between the variables were estimated by the correlations coefficient of determination (r) using the bivariate Pearson correlation. P value <0.05 was considered statistically significant.

Results

This study included three groups. The first group included subjects with chronic cigarette smokers (n = 40), with a mean age of 31 ± 5.5 years and a mean height of 169 ± 9.7 cm. The second group included chronic WP smokers (n = 40), with a mean age of 33 ± 4.8 years and a mean height of 168 ± 10.1 cm. The third group included smokers of both of WP and cigarettes (n = 20) with a mean age of 33 ± 3.8 years and a mean height of 170 ± 9.1 cm.

Results of PFTs for the first and second groups showed a significant reduction in all parameters when compared with the normal reference values (all P values for water-pipe group were <0.005 except for FVC, where P = 1.000) (Table 1). The mean FEV1/FVC ratio of the third group (smoking both WP and cigarettes) was (82 ± 3.0%) compared to the reference non-smokers for the same age and height (90 ± 0.5%) with P <0.005; Table 1).

Table 1: Pulmonary function parameters in chronic cigarette smokers (CS; n = 40), water-pipe smokers (WPS; n = 40), and, in smokers of both of CS and WPS (CS-WPS; n = 20) compared to published reference normal non-smokers (RNNSs) of the same age and height. Data shown are mean ± SD and P values. FEV1 in L = forced expiratory volume in the first second, FVC in L = forced vital capacity, and, PEFR in L/Sec = peak expiratory flow rate.

Parameters	CS vs. RNNSs			WPS vs. RNNSs			CS-WPS vs. RNNSs		
	CS	RNNSs	P	WPS	RNNSs	P	CS-WPS	RNNSs	P
FEV1	3 ± 0.3	3.1 ± 0.2	0.152	3 ± 0.2	3 ± 0.2	<0.001	2 ± 0.2	3 ± 0.1	<0.001
FVC	3 ± 0.4	3.5 ± 0.3	0.999	3 ± 0.2	3 ± 0.2	1.000	3 ± 0.2	3 ± 0.1	1.000
FEV1/FVC ratio (%)	88 ± 3.7	90 ± 0.4	0.025	87 ± 4.0	90 ± 0.5	<0.001	82 ± 3.2	90 ± 0.5	<0.001
PEFR	479 ± 4	495 ± 30	0.020	464 ± 39	491 ± 22	<0.001	451 ± 41	493 ± 21	<0.001

As the smoking duration in years increases, FEV1/FVC ratio deteriorates (Table 2). The mean FEV1/FVC ratio of the cigarette smokers group was 90 ± 2.0 with a duration of 5 years, 86 ± 3.5 with a duration of >5 - 10 years, and, 88 ± 3.7 at >10 years duration. In WP smokers group, increasing the duration of smoking reduced the mean FEV1/FVC ratio from 90 ± 2.5 at 5 years duration to 84 ± 1.3 for >5 - 10 years duration, and to 86 ± 8.6 at >10 years duration. In the third group that smoked both cigarette and WP, increasing the duration of smoking reduced the mean FEV1/FVC ratio from 84 ± 2.0 at 5 years duration to 80 ± 3.5 at >5 - 10 years duration, and to 81 ± 4.5 for >10 years duration. In the third group, the parameters were slightly higher than the second group because the sample size was small in comparison to the second one.

Table 2: The relationship between the duration of tobacco smoking (DTS; in years) and the change in the pulmonary function test mean FEV1/FVC ratio in Sudanese water-pipe smokers (WPS) as compared to cigarette smokers (CS) and smokers of both of CS and WP (CS-WPS). They were compared to published reference normal non-smokers (RNNSs) with the same age and height. Data shown are mean ± SD and P values.

DTS	FEV1/FVC Ratio								
	CS	RNNSs	P	WPS	RNNSs	P	CS-WPS	RNNSs	P
5	90 ± 2.0	90 ± 0.2	0.01	90 ± 2.5	91 ± 0.4	<0.001	84 ± 2.0	90 ± 0.2	<0.001
>5 - 10	86 ± 3.5	90 ± 0.5	<0.001	84 ± 1.3	90 ± 0.5	<0.001	80 ± 3.5	90 ± 0.5	<0.001
>10	88 ± 3.7	90 ± 0.4	<0.001	86 ± 8.6	90 ± 0.5	<0.001	81 ± 4.5	90 ± 0.4	<0.001

The effect of regular exercise on FEV1/FVC ratio of smokers is shown in Table 3. The lung functions in cigarette smokers who were practicing regular exercise were normal with mean FEV1/FVC ratio of (92 ± 2.6) compared to non-exercising smokers, who showed lower mean FEV1/FVC ratio (86 ± 2.6; P = 0.001). Similarly, the lung functions in WP smokers who were practicing regular exercise were normal with mean FEV1/FVC ratio of 93 ± 2.9 compared to non-exercising smokers, who showed deteriorating lung function parameters with mean FEV1/FVC ratio of 85 ± 2.4; P = 0.001). The lung functions in WP and cigarette smokers who were practicing regular exercise were had function than than cigarettes and WP smokers, with a mean FEV1/FVC ratio of 87 ± 0.5, where as in non-exercising smokers, it showed a significant deterioration with a mean FEV1/FVC ratio of 83 ± 5.3; P = 0.001).

Table 3: The effect of practicing regular exercise (PRE) on mean FEV1/FVC ratio of participating Sudanese water-pipe smokers (WPS), cigarette smokers (CS) and smokers of both of CS and WP (CS-WPS). Data shown are mean ± SD & P value.

PRE	FEV1/FVC Ratio		
	CS	WP	CS-WPS
Yes	92 ± 2.6	93 ± 2.9	87 ± 0.5
No	86 ± 2.6	85 ± 2.4	83 ± 5.3
P	<0.001	<0.001	<0.001

The effect of the frequency of cigarette smoking per day on FEV1/FVC ratio is shown in Table 4. In the cigarette smoking group, there was a linear dose-effect on lung functions, where FEV1/FVC ratio decreased from 90 ± 2.81 in people smoking 5 - 10 cigarettes /day to 85 ± 2.93 in people smoking >10 cigarettes /day (P <0.001).

Table 4: The effect of increasing numbers of cigarettes smoked /day (NCS/day) on mean FEV1/FVC ratio of the participating Sudanese smokers. Data shown are mean ± SD and P value of ANOVA test.

NCS/day	FEV1/FVC Ratio	P
5-10	90 ± 2.8	0.080
>10	85 ± 2.9	
P	<0.001	

Increasing the number of WP smoking sessions reduced mean FEV1/FVC ratio from 89 ± 3.14 in people who smoked 3 times/week to 85 ± 2.94 in people who smoked 4 times/week, and, to 86 ± 6.03 in people who smoked >4 times/week. P was <0.001 comparing 3 times smokers vs. 4 times smokers, and was nonsignificant comparing 4 times smokers vs. >4 times smokers. The latter could be due to the smaller number of participants in the latter group (Table 5).

Table 5: The effect of increasing numbers of water-pipe smoking sessions /week (NWPS/week) on mean FEV1/FVC ratio of the participating Sudanese smokers. Data shown are mean ± SD and P value of ANOVA test.

NWPS/week	FEV1/FVC Ratio	P
3	89 ± 3.1	0.000
4	85 ± 2.9	
>4	86 ± 6.0	

Table 6 shows that there was a significant dose-dependent correlation between increasing the duration of WP smoking session and pulmonary functions (P <0.003). The mean FEV1/FVC ratio was reduced from 88 ± 3.05 in people who smoke 30 minute in one session to 85 ± 5.90 in people who smoke 30 - 60 minute in one session, and, to 82 ± 1.25 in people who had smoking session lasting for >1 hour.

Table 6: The effect of increasing the duration of water-pipe smoking session (DWPS) on mean FEV1/FVC ratio in participating Sudanese smokers compared to published reference normal non-smokers (RNNSs) with the same age and height. Data shown are mean ± SD and P values.

DWPS, Minutes	FEV1/F VC ratio		P
	WPS	RNNSs	
30	88 ± 3.0	90 ± 0.5	<0.001
30 - 60	85 ± 5.9	90 ± 0.6	<0.001
>60	82 ± 1.2	90 ± 0.5	<0.001

Discussion

Most of the previous smoking studies done in Sudan were focused mainly on cigarette smoking. To our knowledge none has been done on WP smoking. This study determines the effects of Shisha smoking on lung function among Sudanese adult males in Khartoum. All of the investigated PFTs (FEV1, FVC, FEV1/FVC ratio and PEFR) in our cigarette smokers group were low compared to published reference values for non-smoker Sudanese. We did not include non-smokers in this study; but we compared the results of smokers to Sudanese published reference normal values of the same age and height.

Our results were in agreement with the previous publication of Tantisuwat et al which concluded that FVC of the control non-smokers was significantly greater than those of smokers and that the early effects of cigarette smoking found in youths may lead to problems with the respiratory system[20]. In the present study, there was a significant reduction in all PFTs of chronic WP smokers group compared to their age and height matched reference values. Similar results were reported by Ayoub et al who found a significant decline in PFTs of shisha smokers including FEV1, FEV1/FVC ratio, FEF-25%, FEF-50%, FEF-75%, and FEF-75-85% compared to their age, height, weight and ethnicity matched non-shisha smoker subjects[13].

Our shisha smokers had decreased PFTs than cigarette smokers. Moreover, increasing the duration in years and frequency of WP smoking sessions /week, and, the duration of WP session caused

bigger reduction in PFTs. WP smokers for >10 years was associated with significant decrease in FEV1/FVC ratio, which may indicate inclination to an obstructive pattern in this group, in spite of the exclusion of all known cases of obstructive lung disease. This could be due to the high amount of toxins in one session of shisha smoking, which is equivalent to smoking 100 cigarettes[10,11]. In agreement, Al-Fayez et al reported similar harmful effects for shisha and cigarette smoking on the function of ventilatory capacity of both male and female subjects that increases risk of developing obstructive airway disease, with shisha smokers being at a greater risk[14]. However, another study suggested that WP smoking does not affect pulmonary functions as seriously as cigarette smoking[16].

Our study also showed that, there is dose effect of cigarette smoking on lung functions measured as reduction in mean FEV1/FVC ratio. This was in agreement with Isabel et al showing a significant deterioration in FEV1 and FEV1/FVC ratio that increased with increasing number of cigarettes smoked per day[22].

Considering the effect of regular exercise on the negative effects of tobacco smoking on PFTs, our study showed that regular exercise normalized PFTs compared with non-exercising smokers. This was in agreement with the results of Garcia et al stating that regular physical activity of moderate to high intensity are associated improved PFTs among smokers compared with low physical activity group[23].

Conclusions

We noticed that both types of tobacco smoking (cigarette and water-pipe) produced harmful effects on the pulmonary system as evident from reduction in the measured PFTs (FEV1, FVC, FEV1/FVC ratio, PEFR). This makes the individual at risk of developing obstructive airway disease. Among WP smokers, those with longer smoking duration, those smoked more frequently and those none regularly exercising were at a greater risk. This indicates the urgent need to increase the health awareness regarding cigarette and WP smoking and their harmful effects on pulmonary system and to encourage the smokers to quit smoking by developing specialized centers that utilize, e.g., support groups, nicotine replacement therapy and other medications that can help smokers to stop smoking.

Limitations of the study

The study was faced by some difficulties in including data about the female smokers because it is not socially acceptable. The small sample size of this cross-sectional study necessitates subsequent lager and longitudinal future studies.

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Conflict of Interests

The authors declared no conflict of interests.

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