


Biochemical Data and Metabolic Profiles of Male Exclusive Narghile Smokers (ENSs) Compared With Apparently Healthy Nonsmokers (AHNSs)

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Abstract

Studies evaluating the metabolic profiles of ENSs are scarce and presented controversial conclusions. This study aimed to compare the metabolic profiles of ENSs' and AHNSs' groups. Males aged 25–45 years and free from a known history of metabolic and/or cardiovascular diseases were included. According to the smoking status, two groups of ENSs and AHNSs were identified. Body mass index (BMI, kg/m²), waist circumference (WC, cm), systolic and diastolic blood pressures (SBP, DBP, mmHg), fasting blood data in mmol/L (blood glycemia [FBG], triglycerides [TG], total cholesterol [TC], high- and low- density lipoprotein cholesterol [HDL-C, LDL-C]) and obesity status were evaluated. The metabolic syndrome (MetS) was defined according to the 2006 International Diabetes Federation (IDF) recommendations. Data were expressed as mean \pm standard deviation (SD) or percentages. Compared to the AHNSs' group ($n = 29$), the ENSs' one ($n = 29$) had (a) higher values of BMI (26.5 ± 2.3 vs. 28.2 ± 3.6), WC (95 ± 7 vs. 100 ± 10), and TG (1.22 ± 0.40 vs. 1.87 ± 0.85); and (b) included a lower percentage of males having low HDL-C (82.7% vs. 62.0%), and higher percentages of males having obesity (6.9% vs. 37.9%) or hypertriglyceridemia (10.7% vs. 51.7%). Both the ENSs' and AHNSs' groups: (a) had similar values of FBG (5.38 ± 0.58 vs. 5.60 ± 0.37), TC (4.87 ± 1.16 vs. 4.36 ± 0.74), HDL-C (0.92 ± 0.30 vs. 0.82 ± 0.21), LDL-C (3.09 ± 0.98 vs. 2.92 ± 0.77), SBP (117 ± 9 vs. 115 ± 8), and DBP (76 ± 6 vs. 73 ± 7); and (b) included similar percentages of males having normal weight (17.2% vs. 31.0%); overweight (44.8% vs. 62.1%); android obesity (79.3% vs. 59.6%), hypertension (10.3% vs. 10.3%), hyperglycemia (37.9% vs. 48.2%), and MetS (51.7% vs. 34.5%). There is a need to monitor narghile use among male metabolic patients since it alters some components of the MetS.

Keywords

Tobacco, hookah, endocrinology, biochemical data, metabolic syndrome

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Smoking is a real health problem worldwide (Taghizadeh, Vonk, & Boezen, 2016; WHO, 2017). Current cigarette smoking and lifetime persistent smoking were associated with an increased risk of all-cause, cardiovascular diseases (CVDs), chronic obstructive pulmonary disease, any cancer, and lung cancer mortality (Taghizadeh et al., 2016). Another old form of tobacco use, namely narghile use, is regaining popularity (Van Der Merwe, 1975; WHO, 2015). The Eastern Mediterranean region has the highest prevalence of narghile use in the world, especially among young people (Akl et al., 2011; Shihadeh, Azar, Antonios, & Haddad, 2004). In North Africa, narghile use was reported by 3.5% of the general population and the majority of narghile smokers (NSs) were

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males (82.0%; Alzaabi et al., 2017). This rate is probably lower than reality, since only participants aged 40–49 years were included (Alzaabi et al., 2017). This smoking habit poses great health threats presently. Faced with the “globalization” of the narghile-use phenomenon, the World Health Organization (WHO) has taken up the case and stressed that “it is not only a health risk, but it is also a gateway to smoking for a number of young people” (WHO, 2008a, 2015).

Habitually, public opinion, and particularly the medical world, misjudges the harmful effects of narghile use, despite its damaging effects on health (Aslam, Saleem, German, & Qureshi, 2014; Ben Saad, 2010; Bou Fakhreddine, Kanj, & Kanj, 2014; Chaouachi, 2006, 2009, 2015; El-Zaatari, Chami, & Zaatari, 2015; Waziry, Jawad, Ballout, Al Akel, & Akl, 2017). Up-to-date evidence indicates that narghile use is associated with several adverse health effects including cardiorespiratory, hematological, and reproductive systems (Aslam et al., 2014; Ben Saad, 2010; Bou Fakhreddine et al., 2014; Chaouachi, 2006, 2009, 2015; El-Zaatari et al., 2015; Waziry et al., 2017). An association between narghile use and malignancies, such as lung, oral, and nasopharyngeal cancer, has been suggested (Ben Saad, 2010; Bou Fakhreddine et al., 2014; El-Zaatari et al., 2015; Khemiss, Rouatbi, Berzougua, & Ben Saad, 2016; Waziry et al., 2017). Studies about the effects of narghile use on biochemical data and metabolic profile are scarce (Al Mutairi, Shihab-Eldeen, Mojiminiyi, & Anwar, 2006; Hallit et al., 2017; Koubaa et al., 2015; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018; Shafique et al., 2012). Even in the WHO second edition related to narghile use, no information about its possible effects on smokers' biochemical or metabolic profile was reported (WHO, 2015). To the best of the authors' knowledge, only six studies evaluated the biochemical data and the metabolic profiles of NSs (Al Mutairi et al., 2006; Hallit et al., 2017; Koubaa et al., 2015; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018; Shafique et al., 2012), with controversial conclusions. First, the two studies aiming at evaluating the occurrence of the metabolic syndrome (MetS) in NSs, reported a big gap concerning its prevalence (33.1% [Shafique et al., 2012] vs. 46.8% [Saffar Soflaei et al., 2018]). The comparison of its prevalence between NSs and control groups (Saffar Soflaei et al., 2018; Shafique et al., 2012) identified significant differences between NSs and healthy nonsmokers (HNSs; 33.1 vs. 14.8% [Shafique et al., 2012]; 46.8% vs. 38.8% [Saffar Soflaei et al., 2018]). Second, while some authors reported that NSs and HNSs were matched with fasting blood glycemia (FBG; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018), high- and low- density lipoprotein cholesterol (HDL-C [Al Mutairi et al., 2006; Shafique et al., 2012] and LDL-C [Al Mutairi et al., 2006; Koubaa et al., 2015]), triglycerides (TG; Al Mutairi et al., 2006), and total

cholesterol (TC; Koubaa et al., 2015), others reported that as compared to the HNSs' group, the NSs' one has compromised FBG (Shafique et al., 2012), TG (Koubaa et al., 2015; Saffar Soflaei et al., 2018; Shafique et al., 2012), HDL-C (Koubaa et al., 2015; Saffar Soflaei et al., 2018), LDL-C (Saffar Soflaei et al., 2018), and TC (Saffar Soflaei et al., 2018). Third, while some authors concluded that NSs and cigarette smokers (CSs) were matched with TG (Al Mutairi et al., 2006; Koubaa et al., 2015; Saffar Soflaei et al., 2018), HDL-C (Al Mutairi et al., 2006; Koubaa et al., 2015), LDL-C (Al Mutairi et al., 2006; Koubaa et al., 2015; Saffar Soflaei et al., 2018), and TC (Saffar Soflaei et al., 2018), others reported that as compared to the CSs' group, the NSs' one has compromised FBG (Saffar Soflaei et al., 2018), HDL-C (Saffar Soflaei et al., 2018), and TC (Koubaa et al., 2015). The divergence in conclusions can be related to some methodological limitations and/or differences which may affect the results. Four examples can be highlighted. First, the lack of sample size calculation (Al Mutairi et al., 2006; Koubaa et al., 2015; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018) is a statistically central point since determining the finest size for a study guarantees enough power to distinguish statistical significance and is a serious step in the design of a planned research procedure (Kang, Ragan, & Park, 2008). Second, the inclusion of elderly subjects more than 60 years of age (Al Mutairi et al., 2006; Saffar Soflaei et al., 2018; Shafique et al., 2012) may introduce a bias because the prevalence of altered metabolic data (e.g., MetS) increases with age (Ribeiro, Seixas, Galvez, & Climent, 2018). Third, the lack of information about the different types of the narghile tobacco used (Hallit et al., 2017; Koubaa et al., 2015; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018; Shafique et al., 2012), makes any comparison difficult, because in the case of *tombak* or *jurak*, in comparison to *tabamel*, the pattern is different (Ben Saad, 2009). Fourth, different methods of narghile-use quantification (not reported [Hallit et al., 2017; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018; Shafique et al., 2012], run/day [Al Mutairi et al., 2006], total duration of smoking [Al Mutairi et al., 2006], narghile/year [NY; Koubaa et al., 2015], and quantity in kg of tobacco smoked/year [Koubaa et al., 2015]) were applied. Moreover, the levels of exposure to narghile tobacco, mentioned only in two studies, were imprecise (>five NY [Koubaa et al., 2015], 16 ± 12 years [Shafique et al., 2012]). This situation makes the comparison between studies difficult. Therefore, it is clear that narghile-use research still harbors a lot of deficiencies that need to be further investigated.

Ignoring the damaging effects of narghile use on biochemical and metabolic data will certainly lead to a global public health problem (Ben Saad, 2009, 2010; WHO, 2015), which we can now undertake to prevent. Both the 2005 and 2015 WHO advisory notes on narghile

use (WHO, 2005, 2015) highlighted the above area of deficiency, and among the aspects requiring further research, the epidemiology of narghile-associated disease risk was recommended. Taking into account the aforementioned methodological limitations/differences (Al Mutairi et al., 2006; Hallit et al., 2017; Koubaa et al., 2015; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018; Shafique et al., 2012) and the WHO recommendations (WHO, 2005, 2015), this study aimed to compare the biochemical data and the metabolic profile (especially the presence of a MetS) of exclusive NS (ENSs) with apparently HNSs (AHNSs). The null hypothesis was that there is a divergence between their records.

Population and Methods

Study Design

It was a comparative study performed over a period of 3 months (December 2015 to February 2016) with collaboration between the Departments of Endocrinology and Diabetes, and that of Biochemistry (Farhat HACHED University Hospital, Sousse, Tunisia).

This clinical laboratory report was conducted in agreement with the Declaration of Helsinki. The study approval (number: 2207/2015) was obtained from the Farhat HACHED University Hospital's Ethics Committee. Participants were individually informed about the purpose of the study. Written and informed consent was asked from all study participants who received a report of their explorations. In case of biochemical and/or metabolic abnormalities, participants were cared for by the investigator. Participants were not charged any costs for the accomplished tests.

Sample Size

The null hypothesis (Kang et al., 2008) was $H_0: m_1 = m_2$ and the alternative one was $H_a: m_1 = m_2 + d$; where “ d ” was the difference between two means and n_1 and n_2 were the sample size for two groups (ENSs and AHNSs) such $N = n_1 + n_2$. The total sample size was estimated by using the following formula (Kang et al., 2008):

$$N = \frac{\left(\frac{Z_{\alpha/2} \sqrt{2p(1-p)} + Z_{1-\beta} \sqrt{p_1(1-p_1)p_2(1-p_2)}}{(p_1 - p_2)} \right)^2}{2}$$

- “ $Z_{\alpha/2}$ ” was the normal deviate at a level of significance (=1.96 for 5% level of significance);
- “ $Z_{1-\beta}$ ” was the normal deviate at $1 - \beta\%$ power with $\beta\%$ of Type II error (=1.03 at 85% statistical power);

- “ r ” equal to n_1/n_2 , was the ratio of sample size required for two groups ($r = 1$ gives the sample size distribution as 1:1 for the two groups).
- “ p_1 ” and “ p_2 ” were the proportion of event of interest (e.g., MetS) for two groups, and “ p ” was equal to $(p_1 + p_2)/2$. “ p_1 ” and “ p_2 ” were extracted from the study of Shafique et al. (2012) where the prevalences of MetS were 33.1% and 14.8%, respectively, in ENSs’ and HNSs’ groups. The total sample size for the study was 55 participants (27 ENSs and 27 AHNSs).

Study Population

Participants were selected by convenience sampling applying the following three methods: (a) an informational letter (including the corresponding researcher cell phone number) announcing the need to recruit ENSs was given to the owners of several local cafés which were highly frequented by NSs; (b) acquaintances (usually hospital workers and friends of medical school students) of people involved in this study; and (c) an article announcing the need to recruit participants was posted in a social network service (Facebook pages of the people involved in the study).

Only males aged 25–45 years free from a known history of metabolic and/or CVDs (e.g., diabetes mellitus [DM]; dyslipidemia; arterial hypertension; cerebral vascular stroke; myocardial infarction [MI]) were included. Cigarette smoking and any specific treatment for lipid abnormality were applied as noninclusion criteria. Missing biochemical data and a high amount of cumulated smoked narghile (e.g., >100 NY qualified as outliers) were applied as exclusion criteria.

According to the smoking status, two groups of participants were identified: ENSs’ group of more than five NY and AHNSs’ group. ENSs were instructed not to smoke during the overnight fasting period and before taking the clinical exam and laboratory tests (Al Mutairi et al., 2006; Dzien, Dzien-Bischinger, Hoppichler, & Lechleitner, 2004).

Medical Questionnaire

A nonstandardized medical questionnaire was used to assess several participants’ characteristics: family and personal medical history (DM, arterial hypertension, cerebral vascular stroke, MI, dyslipidemia, thyroid dysfunction); and personal surgical history (e.g., abdominal-pelvic, urologic, orthopedic, neurological); socioeconomic and schooling levels; and smoking (quantity of used narghile and narghile tobacco type) and alcohol habits.

Two schooling levels were defined: low (illiterate, primary education) and high (secondary and university

education; Ben Saad et al., 2014). Two socioeconomic levels were defined according to the occupational status: low (e.g., unskilled worker, jobless) and high (e.g., skilled worker, farmer, manager; National Institute for Statistics and Economic Studies, 1993). Students were classified according to their parents' occupational status. Narghile use and type of narghile tobacco used were self-reported. The narghile-use history was defined as NY (number of narghile smoked a day \times total number of smoking years; Ben Saad, 2009). Three types of used narghile tobacco were evaluated: *moassel* (*tabamel*), *tombak*, and/or *jurak* (Ben Saad, 2009). Alcohol habit was evaluated and two groups of participants were arbitrarily defined: alcohol and nonalcohol consumers.

Anthropometric Data

Age (Yr) was noted. Height (± 0.01 m) was measured with a height gauge shoes removed, heels joined, and back straight. Weight (± 1 kg) was measured with a mechanical scale (*Seca Deutschland*) and the body mass index (BMI, kg/m^2) was calculated. Waist circumference (WC, cm) was measured with a tape measure midway between the lower rib margin and the iliac crest (Bouguerra et al., 2007).

Physical Examination

Systolic and diastolic blood pressures (SBP and DBP) were measured using a manual monitor (*Spengler Vaquez-Laubry, France*) with participants seated for at least 5 min, relaxed and not moving or speaking and the arm supported at the level of the heart (O'Brien et al., 2003).

Biochemical Data

Some biochemical data (FBG [mmol/L]; TG [mmol/L]; TC [mmol/L]; HDL-C [mmol/L]; LDL-C [mmol/L]; uric acid [$\mu\text{mol}/\text{L}$]; creatinine [$\mu\text{mol}/\text{L}$]; urea [mmol/L]) were determined after a 12-hr period of fasting. FBG, TC, HDL-C, creatinine, and urea were quantified by spectrophotometry (Kong et al., 2011). TG and uric acid were quantified by the colorimetric method. LDL-C was calculated (Friedewald, Levy, & Fredrickson, 1972): $\text{LDL-C} = \text{TC} - \text{HDL-C} - \text{TG}/5$.

Applied Definitions

Obesity status was categorized into normal weight ($18.5 \text{ kg}/\text{m}^2 \leq \text{BMI} \leq 24.9 \text{ kg}/\text{m}^2$), overweight ($25.0 \text{ kg}/\text{m}^2 \leq \text{BMI} \leq 29.9 \text{ kg}/\text{m}^2$), and obesity ($\text{BMI} \geq 30.0 \text{ kg}/\text{m}^2$ [WHO, 1999]). The MetS was retained in front of the presence of an android obesity ($\text{WC} \geq 94 \text{ cm}$ [IDF, 2006; WHO, 2008b]) plus any two of the following four factors (IDF, 2006): raised TG ($\geq 1.7 \text{ mmol}/\text{L}$); reduced HDL-C

($< 1.03 \text{ mmol}/\text{L}$); raised SBP ($\geq 130 \text{ mmHg}$) or DBP ($\geq 85 \text{ mmHg}$); and raised FBG ($\geq 5.6 \text{ mmol}/\text{L}$).

Statistical Analysis

The Kolmogorov–Smirnov test was used to analyze variable distributions. Quantitative and qualitative data were expressed as means \pm standard deviation (*SD*) (95% confidence interval [CI]) and as relative number (%), respectively. Mann–Whitney *U* and χ^2 tests were used to compare quantitative data and percentages, respectively. Analyses were carried out using the Statistica statistical software (Statistica Kernel version 6; Stat Software, France). Significance was set at the .05 level.

Results

Sixty-five voluntary participants were included. After applying the noninclusion criteria, only 58 were retained (29 ENSs and 29 AHNSs). The main reasons for noninclusion and/or exclusion were: DM ($n = 4$); antecedents of cerebral vascular stroke ($n = 1$); missing biochemical data ($n = 1$); and cumulated smoked narghile > 100 NY ($n = 1$).

Table 1 displays the characteristics of the participants. The most used tobacco type was *moassel* in almost three-quarter of ENSs. The two groups included similar percentages of males having high socioeconomic or schooling levels, or a normal weight or an overweight. Compared to the AHNSs' group, the ENSs' one was significantly older by ~ 4 years, and had significantly higher weight, BMI, and WC. The ENSs' group included significantly higher percentages of males having obesity or being regular alcoholic consumers.

The two groups were matched with the family and personal medical and surgical histories (Table 2).

Table 3 displays the biochemical data of participants. The two groups had similar values of FBG, TC, HDL-C, LDL-C, urea, SBP, and DBP. Compared to the AHNSs' group, the ENSs' one had significantly higher values of TG and uric acid, but a significantly lower value of creatinine. The exclusion of alcohol consumers provided the same results (Table 1S in the Appendix) except for urea where AHNSs' ($n = 28$) values were significantly higher than those of ENSs ($n = 21$): 5.62 ± 1.36 versus $4.81 \pm 1.05 \text{ mmol}/\text{L}$ ($p = .03$).

Table 4 displays the participants' metabolic profiles. Compared to the AHNSs' group, the ENSs' group included similar percentages of males having android obesity, arterial hypertension, raised FBG, and MetS. The ENSs' group included a significantly lower percentage of males having low HDL-C and a significantly higher percentage of males having hypertriglyceridemia. The exclusion of alcohol consumers provided the same results (Table 2S in the Appendix) except for the

Table 1. Characteristics of the Two Groups of ENSs and AHNSs.

		ENSs (n = 29)	AHNSs (n = 29)	p
Age	(Years)	38 ± 5 (36 to 40)	34 ± 7 (31 to 36)	.018*
Height	(m)	1.77 ± 0.08 (1.74 to 1.80)	1.76 ± 0.07 (1.73 to 1.78)	.272
Weight	(kg)	89 ± 13 (84 to 94)	82 ± 10 (78 to 86)	.027*
Waist circumference	(cm)	100 ± 10 (96 to 103)	95 ± 7 (92 to 98)	.007*
Body mass index	(kg/m ²)	28.2 ± 3.6 (26.9 to 29.6)	26.5 ± 2.6 (25.5 to 27.5)	.046*
Obesity status	Normal weight	5 (17.2)	9 (31.0)	.22
	Overweight	13 (44.8)	18 (62.1)	.17
	Obesity	11 (37.9)	2 (6.9)	.04*
Tobacco quantity	(Narghile-years)	18 ± 15 (12 to 24)	Not applied	
Tobacco type	Tombac	0 (0.0)	Not applied	
	Jurak	4 (13.8)	Not applied	
	Moassel	21 (72.4)	Not applied	
	Jurak and Moassel	4 (13.8)	Not applied	
High schooling level		27 (93.1)	23 (79.3)	.13
High socioeconomic level		25 (86.2)	24 (82.7)	.75
Regular alcoholic consumers		9 (31.0)	1 (3.4)	.006 [‡]

Note. Quantitative data were mean ± SD (95% confidence interval). Qualitative data were number (%). ENSs = Exclusive Narghile Smokers; AHNSs = Apparently Healthy Nonsmokers; p = probability.

*p < .05 (Mann-Whitney U test); ENSs vs. AHNSs. [‡]p < .05 (χ² test); ENSs vs. AHNSs.

Table 2. Family and Personal Medical and Surgical Histories of the Two Groups of ENSs and AHNSs.

		ENSs (n = 29)	AHNSs (n = 29)	p
Family history of:	Mellitus diabetes	15 (51.7)	19 (65.5)	.319
	Arterial hypertension	14 (48.3)	19 (65.5)	.197
	Cerebral vascular stroke and/or myocardial infarction	7 (24.1)	6 (20.7)	.785
	Dyslipidemia	11 (37.9)	10 (34.5)	.752
	Thyroid dysfunction	4 (13.8)	7 (24.1)	.335
Surgical personal history of:	Abdominal-pelvic	4 (13.8)	1 (3.4)	.147
	Urologic	2 (6.9)	0 (0.0)	.152
	Orthopedic	4 (13.8)	3 (10.3)	.641
	Neurological	1 (3.4)	0 (0.0)	.351
	Others	2 (6.9)	1 (3.4)	.487

Note. Data were number (%). ENSs = Exclusive Narghile Smokers; AHNSs = Apparently Healthy Nonsmokers; p = probability.

[‡]p < .05 (χ² test); ENSs vs. AHNSs.

Table 3. Biochemical Data and Blood Pressure Values of the Two Groups of ENSs and AHNSs.

		ENSs (n = 29)	AHNSs (n = 29)	p
Fasting glycaemia	(mmol/L)	5.38 ± 0.58 (4.58 to 6.83)	5.60 ± 0.37 (4.82 to 6.41)	.060
Triglycerides	(mmol/L)	1.87 ± 0.85 (0.74 to 3.71)	1.22 ± 0.40 (0.55 to 2.11)	.001*
Total cholesterol	(mmol/L)	4.87 ± 1.16 (2.97 to 7.30)	4.36 ± 0.74 (3.01 to 5.62)	.076
High-density lipoprotein cholesterol	(mmol/L)	0.92 ± 0.30 (0.50 to 2.05)	0.82 ± 0.21 (0.46 to 1.38)	.129
Low-density lipoprotein cholesterol	(mmol/L)	3.09 ± 0.98 (1.70 to 5.3)0	2.92 ± 0.77 (1.46 to 4.34)	.594
Uric acid	(μmol/L)	324.43 ± 44.07 (235.00 to 438.00)	275.26 ± 62.27 (174.00 to 406.00)	.0009*
Creatinine	(μmol/L)	74.23 ± 12.53 (52.53 to 105.00)	90.46 ± 16.08 (59.00 to 125.00)	.0002*
Urea	(mmol/L)	5.10 ± 1.28 (3.52 to 8.56)	5.64 ± 1.34 (3.41 to 8.53)	.076
Systolic blood pressure	(mmHg)	117 ± 9 (100 to 150)	115 ± 8 (100 to 130)	.479
Diastolic blood pressure	(mmHg)	76 ± 6 (60 to 80)	73 ± 7 (60 to 80)	.123

Note. Data were mean ± SD (95% confidence-interval). ENSs = Exclusive Narghile Smokers; AHNSs = Apparently Healthy Nonsmokers; p = probability.

*p < .05 (Mann-Whitney U test); ENSs vs. AHNSs.

Table 4. Metabolic Profiles of the Two Groups of ENSs and AHNSs.

	ENSs (n = 29)	AHNSs (n = 29)	p
Android obesity	23 (79.3)	17 (59.6)	.08
Systolic blood pressure \geq 130 mmHg	3 (10.3)	3 (10.3)	1.00
Diastolic blood pressure \geq 85 mmHg	0 (0.0)	0 (0.0)	1.00
Hypertension	3 (10.3)	3 (10.3)	1.00
Fasting blood glycaemia \geq 5.6 mmol/L	11 (37.9)	14 (48.2)	.44
Hypertriglyceridemia	15 (51.7)	3 (10.7)	<.001*
Low high-density lipoprotein cholesterol (<1.03 mmol/L)	18 (62.0)	24 (82.7)	.04*
Metabolic syndrome	15 (51.7)	10 (34.5)	.18

Note. Data were number (%). ENSs = Exclusive Narghile Smokers; AHNSs = Apparently Healthy Nonsmokers; p = probability.

*p < .05 (χ^2 test): ENSs vs. AHNSs.

frequencies of participants with a low HDL-C who were similar between the ENSs' and AHNSs' groups (65.0% vs. 82.1%; $p = .187$).

Discussion

Two groups of 29 ENSs of more than five NY and 29 AHNSs were compared. On the one hand, the ENSs' group included a significantly lower percentage of males having low HDL-C (62.0% vs. 82.7%), but significantly higher percentages of males having obesity (37.9% vs. 6.9%) or hypertriglyceridemia (51.7% vs. 10.7%). On the other hand, the two groups of ENSs and AHNSs included similar percentages of males having normal weight (17.2% vs. 31.0%); overweight (44.8% vs. 62.1%); android obesity (79.3% vs. 59.6%), arterial hypertension (10.3% vs. 10.3%), raised FBG (37.9% vs. 48.2%), and MetS (51.7% vs. 34.5%). However, narghile use alters some biochemical data such as TG and uric acid: compared to the AHNSs' group, the ENSs' one had significantly higher values of TG (1.22 ± 0.40 vs. 1.87 ± 0.85 mmol/L) and uric acid (275.26 ± 62.27 vs. 324.43 ± 44.07 μ mol/L). To the best of the authors' knowledge, this is the first specific comparative study exploring the adverse effects of narghile use on some biochemical data and metabolic profile. Box 1 highlights the novelty of this study compared to what is known in this area.

For some years, narghile use has been considered as a global threat and has been given the status of an epidemic by public health officials (Aslam et al., 2014). The harmful effects of narghile use on smokers' biochemical data and metabolic profile highlighted in this study are part of a more general phenomenon (Ben Saad, 2010; Bou Fakhreddine et al., 2014; Chaouachi, 2015; El-Zaatari et al., 2015; Khemiss et al., 2016; Waziry et al., 2017). Although the harmful effects of cigarette consumption on health have been well documented, those of narghile use on biochemical data and/or metabolic profiles are less studied. A 2017 updated systematic review and meta-analysis (Waziry et al., 2017), including just one study

Box 1. Highlights: Novelty of the present research compared to what is known in this area.

WHAT IS KNOWN IN THIS AREA

- According to the 2015 WHO advisory notes on narghile use, studies related to the epidemiology of narghile-associated disease risk are recommended.
- Studies about the effects of narghile use on biochemical data and metabolic profile are scarce and reported controversial conclusions.

NOVELTY OF THE PRESENT RESEARCH

- This study aimed to compare the biochemical data and the metabolic profile of ENSs ($n = 29$) with AHNSs ($n = 29$).
- Compared to the AHNSs' group, the ENSs' one had higher values of BMI, WC, and TG. The ENSs' group included a lower percentage of participants having low HDL-C, but higher percentages of participants having obesity or hypertriglyceridemia.
- ENSs' and AHNSs' groups had similar values of FBG, TC, HDL-C, LDL-C, and BP. The two groups included similar percentages of participants having normal weight; overweight; android obesity, hypertension, hyperglycemia, and metabolic syndrome.

IMPLICATIONS FOR FUTURE RESEARCH

- There is a need to monitor narghile use among metabolic patients and include this information in their medical charts in the same manner cigarette consumption is documented.

(Shafique et al., 2012), reported that narghile use is likely to be associated with MetS (odds ratio [OR]: 1.63–1.95). Studies analyzing the biochemical data and the metabolic profile of ENSs are scarce, and to the finest of the authors' knowledge, only six have been published (Al Mutairi et al., 2006; Hallit et al., 2017; Koubaa et al., 2015; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018; Shafique et al., 2012). Their designs and the characteristics of included participants were exposed in Table 3S (Appendix). The aforementioned studies had several methodological limitations and yielded conflicting results (Tables 4S and 5S, Appendix). As specialists in the field of endocrinology and metabolic diseases are almost certain to encounter NSs amongst their patients, it is

important to inform them of the significantly detrimental impacts of narghile use on smokers' biochemical data and how it can really lead to some metabolic problems.

Nosology

Narghile is a sort of tobacco smoking. Charcoal heats tobacco which produces smoke that passes through water before being inhaled. Additional information about the different synonyms used to refer to narghile, the different names for the tobacco smoked during narghile use, and the different parts of a modern narghile are highlighted in the Appendix.

Discussion of the Methodology

Discussion relative to the following points is highlighted in the Appendix: study design, sample size, applied medical questionnaire, narghile-use quantification, used tobacco, exposure level, number of examiners, and statistical analysis. Only the inclusion and the noninclusion criteria, the recruitment method, the comparison with control groups; the collected data, the applied definitions, and the study limitations will be discussed.

The noninclusion criteria varied between relative studies (Table 3S). This makes the comparison between their data difficult. Since the prevalence of MetS is sex dependent (Rochlani, Pothineni, & Mehta, 2015) and increases with age (Ribeiro et al., 2018) and since some biochemical data are directly associated with sex (e.g., males experienced greater FBG levels than females [Mahassni & Alajlany, 2017]), only males aged 20–45 years were included. In relative studies, age varied between 18 years (Hallit et al., 2017) and 75 years (Shafique et al., 2012), and in some, both sexes were included (Al Mutairi et al., 2006; Hallit et al., 2017; Mahassni & Alajlany, 2017; Shafique et al., 2012; Table 3S). All similar studies reported the “exclusive” character of the narghile use (Al Mutairi et al., 2006; Hallit et al., 2017; Koubaa et al., 2015; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018; Shafique et al., 2012). This is a strong point, because ignoring the profile of volunteers participating in the experiment is a methodological error (Chaouachi, 2006). The body keeps a memory of the smokers' physiological and behavioral practices (Chaouachi, 2009). For this reason, only ENSs should be evaluated in the group of NSs. Some important noninclusion criteria (e.g., known history of metabolic and/or CVDs and any specific treatment for lipid abnormality) known to modify the biochemical data were applied in order to avoid any confusion. In this study, the type of narghile tobacco (*moassel* and/or *jurak*) was identified. This important information, neglected in some studies (Hallit et al., 2017; Koubaa et al., 2015; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018; Shafique et al., 2012), makes

comparisons complicated because in case of other used narghile tobacco (such as *tombak* frequently used in Saudi Arabia) in comparison to *tabamel*, the pattern is different (Ben Saad, 2009). It is established that socioeconomic and/or schooling levels impact the prevalence of MetS with higher education and/or income associated with lower prevalence (Kim, Kim, & Jee, 2018). In the study of Shafique et al. (2012), the socioeconomic levels of the ENSs and HNSs were different (Tables 3S and 4S). In this study, the two groups were matched with the socioeconomic and schooling levels. The two groups higher percentages of participants with high socioeconomic and schooling levels (Table 1) reflected the “real life” as previously seen in a local study aiming at evaluating the smokers' handicap status (Ben Hadj Mohamed & Ben Saad, 2016) or in a Libyan study (Sugathan & Swaysi, 2014) where 75.2% and 86.6% of ENSs were, respectively, having education up to secondary school or college and of high income group. The higher frequencies of android obesity (59.6%) and MetS (34.5%) observed in the AHNSs' group also reflect the “real life” of Tunisian male adults (Gannar et al., 2015). In a sample of 393 adults aged 18–75 years and randomly recruited from the general population, the prevalences of android obesity and MetS were respectively, 47.1% and 38.5% (Gannar et al., 2015). As done in some studies, ENSs were recruited via flyers distributed in the local city cafés (Al Mutairi et al., 2006) and AHNSs from acquaintances of people involved in this study (Mahassni & Alajlany, 2017; Shafique et al., 2012). Other recruitment methods, highlighted in Table 3S, were reported. In this study, and as done in some relative ones (Al Mutairi et al., 2006; Hallit et al., 2017; Koubaa et al., 2015; Table 3S), participants were selected by a convenience sampling. Similarly to any study using this recruitment method for its relative ease of access to volunteers, availability and the quickness with which data can be gathered, there was a possibility of volunteer bias (Ganguli, Lytle, Reynolds, & Dodge, 1998). The inclusion of volunteers during clinical studies leads to a selection bias because researchers may unconsciously approach some kinds of respondents and avoid others, and so the sample might not represent the population as a whole (Lucas, 2014).

As previously carried out by some authors (Al Mutairi et al., 2006; Hallit et al., 2017; Koubaa et al., 2015; Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018; Shafique et al., 2012), a control group of AHNSs was included. In some relative studies, additional control groups of ECSs and/or mixed smokers (MSs) of narghile and cigarettes, and ex-ECSs were included (Table 3S). Taking four groups of HNSs, ENSs, ECSs and MSs (as done by Saffar Soflaei et al., 2018) or three groups of HNSs, ENSs and ECSs (as done by Hallit et al., 2017) into a single study seems to have little precedent in the literature and raises some questions, such as whether the

prevalence of some epidemiological data (e.g., schooling and socioeconomic levels) in those groups was comparable.

As it was carried out in some relative studies (Table 4S), the following anthropometric and fasting blood biochemical data were noted/collected: BMI, WC, SBP, DBP, FBG, TG, TC, HDL-C, LDL-C, uric acid, creatinine, urea. Some additional biochemical data were presented as ratios: HDL-C/LDL-C, HDL-C/TG, and TC/HDL-C (Table 4S). As performed in scarce relative studies (Tables 4S and 5S), the following entities have been also investigated: obesity status, android obesity, low HDL-C, hypertriglyceridemia, hyperglycemia, hypertension, and MetS. As done by Saffar Soflaei et al. (2018), it was better to add an additional entity, such as dyslipidemia (Table 4S). In this study, the MetS was the main outcome used to evaluate the metabolic profile and to calculate the sample size. As done by some authors (Saffar Soflaei et al., 2018; Shafique et al., 2012), the MetS was defined according to the International Diabetes Federation 2006 consensus (IDF, 2006). Compared to this study's MetS criteria, the aforementioned two (Saffar Soflaei et al., 2018; Shafique et al., 2012) had two main differences. These differences concern the applied WC threshold (e.g., for males: 94 vs. 90; Saffar Soflaei et al., 2018; Shafique et al., 2012) and the consideration of specific treatments for lipid abnormality, and/or hypertension and/or MD (Saffar Soflaei et al., 2018; Shafique et al., 2012). In this study, the applied definitions for low HDL-C, hypertriglyceridemia, hyperglycemia, and hypertension were similar to these retained by Shafique et al. (2012).

This study presents three limitations. The major one was the lack of evaluation of the diet regimen and physical activity status of the participants. As highlighted by Shafique et al. (2012), differential dietary intake and physical activity may have confounded the apparent relationship between narghile use and MetS and/or biochemical data. On the one hand, one meta-analysis concluded that low glycemic index diets reduce TC and LDL-C but have no effect on HDL-C or TG (Goff, Cowland, Hooper, & Frost, 2013), and another study identified that a vegetarian diet was associated with lower HDL-C concentrations (Jian et al., 2015). On the other hand, "light" and "moderate-to-vigorous" physical activities had a differential effect on risk markers of cardio-metabolic health (Duvivier et al., 2018). One meta-analysis indicated that dietary and/or physical activity interventions for MetS reduce android obesity with no adverse effects (Duvivier et al., 2018). BMI was evaluated as another proxy measure of dietary intake and physical activity. As compared to the AHNSs' group, the ENSs' one had a higher BMI and included a higher percentage of obese males (Table 1), so we can hypothesize that the two groups had

different diet regimens and physical activity status. Given that narghile is smoked in gatherings with people sitting around, exposure to second-hand smoke may have some influence on this study's results. Some of the AHNSs may have been exposed to second-hand smoke through contaminated air and this resulted in an impairment in their metabolic profile as well. If this was true, it is unlikely to affect the observed relationship of narghile use and MetS. However, the harmful effects of narghile use observed in this study may have been attenuated and true effect may even be stronger than the observed effect. The last limitation concerns the inclusion of a higher percentage of ENSs who were regular alcohol consumers (Table 1). This could be a source of confusion and could influence some reported biochemical data (De Oliveira et al., 2000; Ejilemele & Orluwene, 2010). In fact, biochemical abnormalities (e.g., hypoglycemia, high HDL-C) are common among chronic alcoholics (De Oliveira et al., 2000; Ejilemele & Orluwene, 2010). However, according to the literature, it seems that among lifetime NSs, 17% (Jawad, McEwen, McNeill, & Shahab, 2013) to 28.6% (Danaei, Jabbarinejad-Kermani, Mohebbi, & Momeni, 2017) were lifetime alcoholics. Moreover, Hallit et al. (2017) reported that 73.3% of current CSs who were current NSs were alcohol consumers. Consequently, it seems that this study ENSs' group reflected the "real life" of NSs as seen in practice. Moreover, a recent meta-analysis suggested that heavy alcohol consumption might be associated with an increased risk of MetS while very light alcohol consumption seemed to be associated with a reduced risk of MetS (Sun et al., 2014).

Discussion of Results

Compared to the AHNSs' group, the ENSs' one had significantly higher weight, BMI, WC, TG, and uric acid, but a significantly lower value of creatinine. The ENSs' group included a significantly lower percentage of males having low HDL-C; nevertheless, significantly higher percentages of males having obesity or hypertriglyceridemia. Conversely, the two groups included similar percentages of males having normal weight; overweight; android obesity, arterial hypertension, raised FBG, and MetS. Moreover, the latter were matched with FBG, TC, HDL-C, LDL-C, urea, and SBP and DBP values.

Effects on anthropometric data and obesity status. This study's findings concerning weight, BMI, and WC (Table 1) are intermediate between these reported in two similar ones (Koubaa et al., 2015; Shafique et al., 2012; Table 4S). On the one hand, and contrary to this study's findings, Koobaa et al. (2015) reported that the three groups of ENSs, ECSs, and HNSs were matched with weight and BMI. On the other hand, and as noted in this study,

Shafique et al. (2012) reported that compared to the HNSs' group, the ENSs' group had a significantly higher WC (81 ± 12 vs. 85 ± 13 cm). A recent population-based study aiming at evaluating the relationship between narghile use and weight, concluded that daily NSs, compared to HNSs, had higher BMI, translating into 6 extra kilograms of weight on average (Ward et al., 2015).

Compared to the AHNSs' group, the ENSs' group included a higher percentage of obese males (Table 1). This result is in line with that reported by Saffar Soflaei et al. (2018) who noted a positive association between narghile use and obesity, which was not established in case of cigarette consumption (Table 4S). This obesity can be related to the sedentary life style opted by ENSs (Ben Hadj Mohamed & Ben Saad, 2016; Ben Saad et al., 2014).

Effects on blood pressures data. The finding of this study concerning blood pressures (Table 3) is opposite to that reported by Shafique et al. (2012) who noted significantly higher SBP and DBP values in ENSs compared to HNSs (130 ± 22 vs. 124 ± 20 mmHg and 74 ± 10 vs. 72 ± 10 mmHg, respectively). A previous local study aiming at evaluating the deficiency and incapacity of ENSs compared to HNSs identified a significant difference between their DBP (85 ± 10 vs. 78 ± 16 mmHg), nevertheless their SBP were similar (132 ± 13 vs. 129 ± 18 mmHg; Ben Saad et al., 2014). A recent systematic review highlighted that narghile use was associated with an increase in blood pressure (Haddad et al., 2016).

Effects on blood lipid data. Lipid data are an integral part of the search for the factors of cardiovascular risk. The two groups of ENSs and AHNSs were matched with TC, HDL-C, and LDL-C. Compared to the AHNSs' group, the ENSs' group had significantly higher TG values (Table 3). The effects of narghile use on the aforementioned data are controversial (Table 4S).

Similar to this study's findings, some authors reported that compared to the HNSs' group, the ENSs' group had significantly higher TG values (1.6 ± 1.0 vs. 1.4 ± 0.90 mmol/L [Shafique et al., 2012]; 1.38 ± 0.32 vs. 0.9 ± 0.02 mmol/L [Koubaa et al., 2015]). In some other studies, no statistical difference between TG values of ENSs as compared to HNSs (Al Mutairi et al., 2006; Saffar Soflaei et al., 2018), to ECSs (Al Mutairi et al., 2006; Koubaa et al., 2015; Saffar Soflaei et al., 2018), to MSs (Saffar Soflaei et al., 2018), and to ex-ECS (Saffar Soflaei et al., 2018) was found.

Similar to this study's findings, no statistical difference between TC values of ENSs as compared to HNSs was identified in a Tunisian study (Koubaa et al., 2015). Comparison of ENSs TC values with these of ex-ECSs (Saffar Soflaei et al., 2018) or MSs (Saffar Soflaei et al.,

2018) reported similar data. Saffar Soflaei et al. (2018) reported that compared to the HNSs' group, the ENSs one had significantly lower TC values (4.93 ± 0.97 vs. 4.97 ± 1.02 mmol/L). Comparisons of TC values between ENSs and ECSs are also controversial. While Saffar Soflaei et al. (2018) identified similar data between the two groups, Koubaa et al. (2015) reported that compared to the ECSs' group, the ENSs' group had significantly lower TC values (4.36 ± 0.11 vs. 4.48 ± 0.09 mmol/L).

Akin to the results of this study, no statistical difference between HDL-C values of ENSs compared to HNSs was reported in two studies (Al Mutairi et al., 2006; Shafique et al., 2012). Comparisons of ENSs HDL-C values with those of ECSs (Al Mutairi et al., 2006; Koubaa et al., 2015; Saffar Soflaei et al., 2018), ex-ECSs (Saffar Soflaei et al., 2018), or MSs (Saffar Soflaei et al., 2018) identified similar data. Compared to the HNSs' group, the ENSs' group had significantly lower HDL-C values (1.12 ± 0.12 vs. 0.97 ± 0.05 mmol/L [Koubaa et al., 2015]; 1.12 ± 0.26 vs. 1.09 ± 0.23 mmol/L).

In accordance with this study's findings, no statistical difference between LDL-C values of ENSs compared to HNSs was identified in two studies (Al Mutairi et al., 2006; Koubaa et al., 2015). Comparisons of ENSs LDL-C values with these of ECSs (Al Mutairi et al., 2006; Koubaa et al., 2015; Saffar Soflaei et al., 2018), ex-ECSs (Saffar Soflaei et al., 2018) or MSs (Saffar Soflaei et al., 2018) reported comparable data. One study (Saffar Soflaei et al., 2018) established that compared to the HNSs' group, the ENSs' group had significantly higher LDL-C values (3.01 ± 0.92 vs. 3.03 ± 0.97 mmol/L). It is important to highlight that the LDL-C mean value of ENSs reported by Hallit et al. (2017) (4.24 ± 0.65 mmol/L) was the highest one among all relative studies (Table 4S). Hallit et al. (2017) highlighted two additional results: (a) The LDL-C of ENSs correlated with SBP, DBP, TC, and BMI, but did not correlate with WC, heart rate, HDL-C, TG, and FBG. (b) Among the current CSs who were current NSs, a significant increase in LDL-c level was observed relative to current CSs who were not NSs.

Effects on FBG. The effects of narghile use on FBG are controversial (Table 4S). Akin to this study's findings, some authors (Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018) identified no difference between FBG values of ENSs as compared to HNSs (Mahassni & Alajlany, 2017; Saffar Soflaei et al., 2018), ex-ECSs (Saffar Soflaei et al., 2018), or MSs (Saffar Soflaei et al., 2018). In other studies (Saffar Soflaei et al., 2018; Shafique et al., 2012), FBG mean values were significantly higher in ENSs as compared to HNSs (5.2 ± 1.7 vs. 4.9 ± 1.2 mmol/L; Shafique et al., 2012) or to ECSs (5.14 ± 2.33 vs. 4.86 ± 1.88 mmol/L; Saffar Soflaei et al., 2018).

Effects on uric acid, urea, and creatinine data. Only one related study (Saffar Soflaei et al., 2018) evaluated the abovementioned data. Contrary to this study's results, where compared to the AHNSs' group, the ENSs' group had a significantly higher uric acid mean value (Table 3), Saffar Soflaei et al. (2018) reported that the two groups were matched for this data (Table 4S). The authors indicated that compared to the ECSs' group, the ENSs' one had lower uric acid values (274.82 ± 83.28 vs. 259.33 ± 78.51 $\mu\text{mol/L}$; Saffar Soflaei et al., 2018). Contrarily to these study results, where compared to the AHNSs' group, the ENSs' one had a significantly lower creatinine mean value (Table 3), Saffar Soflaei et al. (2018) revealed that the two groups matched this data (Table 4S). The authors reported no significant difference between ENSs and ECSs or ex-ECSs or MSs. Similarly, to this study findings (Table 3), Saffar Soflaei et al. (2018) indicated that the ENSs' and ECSs' groups were matched with the urea values (Table 4S).

Effects on metabolic profile. Only one previous study (Shafique et al., 2012) evaluated the metabolic profile of ENSs and HNSs (Table 5S). The authors (Shafique et al., 2012) noted that compared to HNSs, ENSs were significantly more likely to have hypertriglyceridemia (OR: 1.60), hyperglycemia (OR: 1.88), hypertension (OR: 1.31), and android obesity (OR: 1.21). In a Libyan cross-sectional study including 242 regular ENSs, prevalences of hypertension, DM, and ischemic heart disease were 44.5%, 33.9%, and 8.5%, respectively (Sugathan & Swaysi, 2014). The aforementioned reported health problems were significantly higher among NSs aged 35 years and more, with a narghile duration-use higher than 20 years, and who smoked more than thrice a week (Sugathan & Swaysi, 2014).

The unexpected lower percentage of ENSs having low HDL-C (62.0%) compared to that observed in AHNSs (82.7%) can be explained by the higher frequency of alcohol consumers included in the ENSs group (Table 1; Dai et al., 1985; De Oliveira et al., 2000). Indeed, the exclusion of alcohol consumers provided comparable percentages between the two groups (Table 2S). In fact, it was previously identified that alcohol consumption increases HDL-C in a dose-dependent fashion, associated with and possibly caused by, an increase in the transport rate of HDL apolipoproteins apoA-I and -II (De Oliveira et al., 2000).

Smoking has been consistently linked with CVD; recent evidence suggests that MetS is the potential link between tobacco smoking and CVDs (Dzien et al., 2004). MetS is a cluster of risk factors which have revealed a strong relationship with the risk of CVDs. Individuals with MetS are twice as likely to die from CVDs, and three times more likely to have a heart attack/stroke compared with people without MetS (IDF, 2006). The unexpected

result concerning the frequencies of MetS (Table 4) is contrary to that observed in two previous studies (Saffar Soflaei et al., 2018; Shafique et al., 2012; Table 5S). On the one hand, Shafique et al. (2012) reported that age adjusted-prevalence of MetS was significantly higher among ENSs (33.1%) compared with HNSs (14.8%). ENSs were three times more likely to have MetS compared with HNSs after adjustment of age, sex, and social class (Shafique et al., 2012). Saffar Soflaei et al. (2018) noted a positive association between narghile use and MetS, which was not established in cigarette consumption. Prevalence of MetS was significantly higher in ENSs (46.8%) in comparison with HNSs (38.8%). The higher percentage of ENSs who were lighter alcohol consumers can be advanced to explain the lack of a significant difference between the two groups concerning the frequency of MetS, since very light alcohol consumption seemed to be associated with a reduced risk of MetS (Sun et al., 2014). The above hypothesis cannot be retained since a similar result was observed after exclusion of alcohol consumers (Table 2S).

Other interesting results, relative to percentages of participants with CVDs, or DM, or dyslipidemia, were observed by Saffar Soflaie et al. (2018). The authors stated that after adjustment of age and sex, the presence of CVDs (12.9%, 13.6%, 19.0%, 10.0%, and 12.3%, respectively, in NSs, current-CSs, ex-CSs, MSs, and HNSs), DM (17.1%, 9.8%, 18.9%, 16.2%, and 14.0%, respectively in NSs, current-CSs, ex-CSs, MSs, and HNSs), and dyslipidemia (67.1%, 75.1%, 70.9%, 80.5%, and 65.5%, respectively in NSs, current-CSs, ex-CSs, MSs, and HNSs) was significantly related to the smoking status. Moreover, dyslipidemia was associated with narghile use. In a Lebanon study performed on patients undergoing cardiac catheterization, Platt et al. (2017) noted that MI was significantly and independently associated with narghile use (OR: 1.33), which is lower than that for cigarette consumption (OR:1.87). Moreover, only DM presented significant association with narghile use among MI enrollees (OR: 1.66).

Underlying mechanisms of narghile use. These study findings are biologically plausible in many ways related to the harmful effects of the narghile smoke compounds. The biological mechanisms responsible for the effects of narghile use on smokers' biochemical data are not elusive. Some mechanisms, related to the effects of some deleterious gases included in the narghile smoke, are advanced and detailed in the Appendix.

Public Health Implications

Health education and awareness are perhaps the most crucial interventions required to be delivered for NSs, so

that the false perceptions about the narghile-use harmlessness can be changed and its adverse effects could be assessed by the community. There is a need to monitor narghile use among metabolic patients and include this information in their medical charts in the same manner that cigarette consumption is documented. This is likely to increase awareness of the hazards of narghile use and prompt physicians to target narghile tobacco control by providing their patients with advice about narghile-use cessation.

In conclusion, narghile use alters some metabolic data (e.g., TG, uric acid, and creatinine) and some constituents of MetS (e.g., hypertriglyceridemia). Thus, global actions against this type of smoking are necessary.

Abbreviations list

AHNSs: apparently healthy nonsmokers
 BMI: body mass index
 CSs: cigarette smokers
 CVDs: cardiovascular diseases
 DBP: diastolic blood pressure
 DM: diabetes mellitus
 ECSs: exclusive cigarette smokers
 ENSs: exclusive narghile smokers
 FBG: fasting blood glycemia
 HDL-C: high-density lipoprotein cholesterol
 HNSs: healthy nonsmokers
 LDL-C: low-density lipoprotein cholesterol
 MetS: metabolic syndrome
 MI: myocardial infarction
 MSs: mixed smokers
 NSs: narghile smokers
 NY: narghile/year
 OR: odds ratio
 SBP: systolic blood pressure
 SD: standard deviation
 TC: total cholesterol
 TG: triglycerides
 WC: waist circumference
 WHO: World Health Organization
 CI: confidence interval

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Authors' contributions

YH, SB, and HBS: Literature search, data collection, study design, analysis of data, manuscript preparation, and review of manuscript.

MM, AM, and SR: Study design, data analysis, manuscript preparation, and review of manuscript.

All authors read and approved the final manuscript.

Declaration of Conflicting Interests

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Supplemental Material

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