Investigation of Exclusive Narghile Smokers: Deficiency and Incapacity Measured by Spirometry and 6-Minute Walk Test

Helmi Ben Saad MD PhD, Maya Babba MD, Rafik Boukamcha MSc, Ines Ghannouchi MD, Imed Latiri PhD, Sonia Mezghenni MD, Chakib Zedini MD, and Sonia Rouatbi MD PhD

BACKGROUND: Studies on the submaximal aerobic capacity of exclusive narghile smokers (ENS) seem necessary in view of effective prevention of cardiorespiratory diseases. The goal of the study was to assess, by 6-min walk test (6MWT) data, the submaximal aerobic capacity of ENS, to identify factors influencing their 6-min walk distance (6MWD), and to compare their data with those of a healthy non-smoker (HNS) group. METHODS: Seventy 20–60-y-old male ENS were included. Narghile use (narghile-years) and anthropometric, clinical, spirometric, and 6MWT data were collected. Univariate and multivariate analyses were used to identify factors influencing 6MWD. Data of a subgroup of 40–60-y-old ENS ($n = 25$) were compared with those of an age-matched HNS group ($n = 53$). RESULTS: The median (first to third quartile) for age and narghile use were 32 (26–43) and 17 (8–32) narghile-years, respectively. The profile of ENS performing the 6MWT was as follows: at the end of the 6MWT, 34% and 9% had a low heart rate (< 60% of maximum predicted) and high dyspnea scores (> 5/10, visual analog scale), respectively; 3% had an oxyhemoglobin saturation decrease of > 5 points during the test; and 20% had an abnormal 6MWD (less than the lower limit of the normal range). The factors that significantly influenced the 6MWD, explaining 38% of its variability, are included in the following equation: 6MWD (m) = 742.63 − 5.20 × body mass index (kg/m^2) + 25.23 × FEV$_1$ (L) − 0.44 × narghile use (narghile-years). Compared with HNS, the subgroup of ENS had a significantly lower 6MWD (98 ± 7 vs 87 ± 9% predicted, respectively). CONCLUSIONS: Narghile use may play a role in reducing submaximal aerobic capacity. The present study suggests that a program of pulmonary rehabilitation is an excellent axis to follow. *Key words: smoking; narghile; tabamel; deficiency; incapacity; walk test.* [Respir Care 2014;59(11):1696–1709.

Introduction

Tobacco smoking using a narghile is considered a public health threat.[1-5] It is suspected to be a risk factor for a number of acute and chronic tobacco-related defects and/or diseases.[1-8]

Among the deleterious effects of narghile use, the chronic cardiorespiratory defects are prominent:[9-24] exclusive narghile smokers (ENS) have been shown to exhibit worse respiratory and cardiac profiles than healthy non-smokers

Drs Ben Saad, Ghannouchi, and Rouatbi are affiliated with the Service of Physiology and Functional Exploration, and Dr Mezghenni is affiliated with the Department of Pulmonology, Farhat Hached Hospital, Sousse, Tunisia. Drs Ben Saad, Babba, Ghannouchi, Latiri, and Rouatbi and Mr Boukamcha are affiliated with the Laboratory of Physiology; Dr Ben Saad is affiliated with the Research Unit Secondary Prevention After Myocardial Infarction, N: 04/UR/08-18; and Dr Zedini is affiliated with the Department of Community Medicine, Faculty of Medicine, University of Sousse, Sousse, Tunisia.

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(HNS) (eg, higher heart rate and systolic (SBP) and diastolic (DBP) blood pressures and lower lung flows and/or volumes). In addition, studies have demonstrated acute (immediate) effects of narghile smoke in the form of increased heart rate, breathing frequency, expired carbon monoxide, SBP, or DBP and a decline in lung function.[25-31] However, most of these studies[9-31] have evaluated only changes in basic spirometric and/or cardiac measures at rest.

Although it is important to gauge the effect of narghile smoke exposure on the cardiorespiratory system, resting lung and/or heart function tests may fail to demonstrate the extent of the effect narghile smoke may have on cardiorespiratory function.[10,25,32,33] Adding to lung and heart function tests by including exercise capacity measures to test the impact of narghile smoke exposure is useful in that more subtle changes or effects that emerge only during stressful or dynamic conditions may then become detectable.[10,25,32,33] Characterizing such changes can add to a more comprehensive understanding of narghile smoking impact on critical physiological measures, and generated information can serve as a deterrent when counseling smokers against this seemingly harmless habit.[10,25,32,33]

To the best of our knowledge, studies on maximal and submaximal aerobic capacities of ENS are rare:[10,25,33] two studies had evaluated the chronic effects of narghile smoke on passive animal smokers[33] and on human ENS,[10] and one evaluated its acute effects on human ENS.[25] Sulaiman[33] studied an experimental model of pregnant rats exposed to narghile smoke (daily for 10 min from days 2 to 18 of pregnancy) and examined the effect of smoking on locomotor activity of juvenile rats (ambulatory and stereotype behavior of offspring measured at the age of 30 d). He found that the total ambulatory activity and stereotype movements of exposed rats were 21% (P = .08) and 26% (P = .03) lower than those of matched controls, respectively, and that the decreased rates of ambulatory activity and stereotype movements in exposed rats were 28% (P = .09) and 10-fold (P < .05) lower than those in non-exposed rats, respectively. He concluded that prenatal exposure to narghile smoke lowers the response of offspring to novel environment stimuli.

Koubaa et al[10] studied the chronic effects of narghile smoking on cardiopulmonary capacities of ENS who performed a triangular test with speed walk. For the ENS group, concerning maximum oxygen uptake ($\dot{V}_{O_2}$) and maximum aerobic speed, statistical analysis showed a significant difference compared with the exclusive cigarette smoker group. Hawari et al[25] characterized the acute effects of narghile smoking on exercise capacity of healthy ENS who performed time-limited cardiopulmonary exercise testing. They used a pilot single-group pre-test (abstained from narghile smoking for ≥ 48 h) and post-test (within 0.5 h of a 45-min narghile smoking session). After narghile smoking, the carbon monoxide level increased from 3.7 to 24.4 ppm, $\dot{V}_{O_2}$ decreased from 1.86 to 1.7 L/min, baseline breathing frequency increased from 17.7 to 19.7 breaths/min, maximum mid-expiratory flow decreased from 5.51 to 5.29 L/s, and perceived exertion at mid and peak exercise increased. Baseline resting SBP, pulse pressure, and pulse pressure product increased after narghile smoking (from 119 to 129, from 45 to 56, and from 10 to 11 mm Hg/min, respectively). During exercise, a decrease in oxygen pulse was observed after narghile smoking (from 11 to 10 mL of O_2 consumed/heartbeat), whereas the heart rate-$\dot{V}_{O_2}$ relationship increased after narghile smoking from 3.5 to 3.9 beats/min/mL/kg. The authors concluded that acute narghile smoking appears to induce impairment of exercise capacity.[25]

To better explore the chronic effects of narghile use, it would be interesting to refer to the World Health Organization's latest classification of the natural history of chronic diseases (http://www.who.int/classifications/icf/en/, *Accessed June 10, 2014*), reporting 3 evolutionary stages: deficiency, incapacity, and social disadvantage. The evaluation of incapacity (clinically characterized by dyspnea[21]) is considered essential because it alone can predict the future functioning of the patient. This is the determination of exercise tolerance through, for example, data from a field test such as the 6-min walk test (6MWT), which explores the cardiorespiratory and muscle chain. The so-

QUICK LOOK

Current knowledge

Smoking flavored tobacco via a water pipe, hookah, or narghile represents a significant public health concern. The impact of this type of smoking on cardiorespiratory function is similar to that seen with traditional cigarette smoking.

What this paper contributes to our knowledge

Exclusive narghile smokers had a reduced 6-min walk distance compared with an age-matched control of non-smokers. This reduction in submaximal exercise is an early sign of the progressive negative impact of narghile smoking. Smoking cessation efforts and pulmonary rehabilitation are warranted in this group of smokers as well.

Correspondence: Helmi Ben Saad MD PhD, Laboratory of Physiology, Faculty of Medicine, University of Sousse, Rue Mohamed Karoui, 4002 Sousse, Tunisia. E-mail: helmi.bensaad@rns.tn.

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cial disadvantage is the psychosocial impact of the disease. This is the assessment of the quality of life. The deficiency has already been extensively explored.[7-31] The assessment of functional incapacity, for example, through 6MWT data (endurance test, intensity moderately higher than daily-living activities[34,35]), is desirable. Indeed, the skill of walking is a reflection of the ability to maintain a number of daily-life activities for patients.[34] Therefore, it is an important quality-of-life component.[34]

The present study aimed to add to the current body of literature by evaluating the effects of regular or chronic narghile use on functional capacity utilizing the 6MWT. The main objective of this study, conducted in a population of ENS, was to evaluate their submaximal aerobic capacity through 6MWT data. In addition, the study aimed to compare data from a subset group of ENS (40–60 y) with those of an age-matched HNS control group.

Methods

The methodology of the present study was previously published as a protocol in progress.[32]

Study Design

The present cross-sectional study was performed over a 4-month period (January to April 2010) at the Physiology and Functional Exploration Department of the Farhat Hached Hospital in Sousse, Tunisia. Approval for the study was obtained from the ethics committee of the local hospital, and written consent was obtained from all study participants.

Sample Sizes

ENS Group. The sample size was calculated[36] as follows:

$$n=(Z^2 \times p \times q)/\Delta^2,$$

where n is the number of required ENS, Z is the 95% confidence level (Z = 1.96), q is 1 − p, Δ is precision (8%), and p is the estimation of the 6-min walk distance (6MWD) decline or submaximal aerobic capacity induced by chronic narghile use. Given the pioneering nature of the present work, we referred to a local spirometric study showing that 13% (P = .13) of ENS have an abnormal FEV_1 (FEV_1 < lower limit of the normal range).[16] The sample size was thus 68.

Control Group. Fifty-three 40–60-y-old HNS (neither narghile nor cigarette) were included. Subjects were recruited from the staff of the local faculty of medicine and/or hospital and were also acquaintances of people involved in the study.

ENS Group: Recruitment Method and Inclusion/Non-Inclusion Criteria

ENS were recruited in 3 ways. We had a database of ENS who had previously participated in studies analyzing their spirometric profiles.[17,18] We contacted those who met the inclusion criteria. An article was published in a weekly newspaper announcing the need for recruitment of ENS. Informational letters clarifying the aims of the study were then put up at the hospital and the local medical school.

Only male ENS with a > 5 narghile-year history and 20–60 y old were included. Detailed non-inclusion criteria were: 6MWT contraindications (unstable angina or myocardial infarction during the previous month, resting heart rate ≥ 120 beats/min, resting SBP ≥ 180 mm Hg, and resting DBP ≥ 100 mm Hg)[34]; current or former cigarette or pipe smoking; asthma or recent respiratory infection; diabetes lasting for > 5 y; rheumatologic, orthopedic, or surgical diseases interfering with walking; chronic medication use (especially β blockers, diuretics, and corticosteroids); imperfect realization of the required maneuvers during spirometry; and inability to perform the 6MWT exactly. ENS had to stop smoking at least 24 h prior to testing.

Data Collected

Clinical and sociodemographic characteristics included histories of abdominal surgery, diabetes, dyslipidemia or angina pectoris, coughing and spitting (duration and frequency), dyspnea (Modified Medical Research Council dyspnea scale), obstructive sleep apnea, socioeconomic level, educational level, physical activity scores, sedentary and obesity status, narghile use, and cigarette consumption. Anthropometric data included age (or chronological lung age), weight, height, and body mass index (BMI). Spirometric data included FVC, FEV_1, peak expiratory flow, maximum mid-expiratory flow, FEV_1/FVC, and estimated lung age. 6MWT data included heart rate, oxyhemoglobin saturation, SBP, DBP, dyspnea (visual analog scale), 6MWD, and estimated cardiorespiratory and muscular chain age.

Medical and Physical Activity Questionnaires

Data were collected using a questionnaire modeled on that of the American Thoracic Society Division of Lung Diseases 78 adult medical questionnaire.[37] It was composed of questions asked in local Arabic dialect by the same trained operator (MB). This non-validated questionnaire was used to assess several subject characteristics (educational level, occupational status, smoking, medical and surgical histories, and medication use).

Cigarette consumption and narghile use were evaluated in pack-years and narghile-years, respectively.[3] We considered that a smoked narghile contained 25 g of tobacco (often the tabamel type moassel, unflavored and without glycerol[3]), and thus, 1 narghile-year (one narghile/d for 1 y) = 9.125 kg of cumulative tobacco use.[3]

Subjects were classified as coughing if they coughed 4–6 times per d, 4–6 times per week, and as sputum producer if they spit twice per d, 4 or more times per week.[37]

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

Two socioeconomic levels were defined according to occupational status: unfavorable (eg, unskilled worker, jobless) and favorable (eg, skilled worker, farmer, manager). Students were classified according to their parents' occupational status.

Dyspnea was assessed by the Modified Medical Research Council dyspnea scale,[38] and 2 groups of subjects were identified: no dyspnea (level 1) and dyspnea (levels 2–5).

A translated version of the physical activity questionnaire of Voorrips et al[39] was filled out by each subject, and household, sporting, and leisure activities were evaluated to yield a total physical activity score. According to the total physical activity score, 2 groups of subjects were defined: sedentary (score < 9.4) and active (score ≥ 9.4).

Physical Examination

Age (y) was verified by identity cards. Height ($\pm$ 0.01 m) was measured with a height gauge with shoes removed, heels joined, and back straight. Weight ($\pm$ 1 kg) was measured, and BMI (weight/height^2) was calculated. The following definitions were adopted[40]: underweight (BMI $<$ 18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), moderate obesity (30.0–34.9 kg/m^2), important obesity (35.0–39.9 kg/m^2), and morbid obesity (BMI $>$ 40.0 kg/m^2). Two groups of subjects were defined: non-obese (BMI $<$ 30.0 kg/m^2) and obese (BMI $\geq$ 30.0 kg/m^2).

Electrocardiogram and Spirometry

A 12-lead resting electrocardiogram was performed at baseline. An abnormal reading was not considered as a reason for excluding subjects.

Spirometric measurements (DATOSPIR-120, Sibel SA, Barcelona, Spain) were performed according to international recommendations.[41] The results were compared with local reference values.[42] Spirometric applied definitions were based on the identification of 95% CI and therefore the application of the lower limit of the normal range.[43] A large-airway obstructive ventilatory defect was defined as FEV_1/FVC less than the lower limit of the normal range. A small-airway obstructive ventilatory defect was defined as FEV_1/FVC more than the lower limit of the normal range, FVC more that the lower limit of the normal range, and maximum mid-expiratory flow less than the lower limit of the normal range.[16] Depending on the presence of an obstructive ventilatory defect, 2 groups of subjects were retained: no obstructive ventilatory defect and obstructive ventilatory defect. The estimated lung age was calculated.[44,45] (For additional information about spirometry, see the supplementary materials at http://www.rcjournal.com.)

6MWT Procedure, Dyspnea Evaluation, and Applied Definitions

Only one 6MWT was conducted outdoors according to the American Thoracic Society protocol (for those who are not familiar with conducting a 6MWT).[34] Subjects were told to eat a light meal, to avoid vigorous exercise in the 2 h prior to testing, and to wear comfortable clothes and appropriate walking shoes.[34]

The test was conducted along a seldom-traveled, flat, straight corridor (40 m long, marked every 1 m with cones to indicate turnaround points) with a hard surface. To minimize intraday variability, temperature effects, and biological rhythms, the 6MWT was performed between 2 and 4 PM, a period characterized by a stable ambient temperature of 16–20°C. All subjects performed the 6MWT for the first time with no warm-up period and no encouragement. However, we specified to each subject that he was allowed to stop and rest during the test.

Each subject sat in a chair located near the starting position for at least 10 min before the test started. During this time, resting dyspnea, heart rate, oxyhemoglobin saturation (finger pulse oximeter, Nonin, Plymouth, Minnesota), and blood pressures were measured. The test instructions to the subjects were those recommended by the American Thoracic Society.[34] At the end of the 6MWT, the same data, in addition to 6MWD, were measured. Recommended reasons for immediately stopping the 6MWT include chest pain, intolerable dyspnea, leg cramps, staggering, diaphoresis, and pale or ashen appearance.[34]

In addition to 6MWD (m, % predicted), dyspnea (visual analog scale), SBP and DBP (mm Hg), heart rate (beats/min, % predicted maximum heart rate), oxyhemoglobin saturation, the difference in oxyhemoglobin saturation before and after the 6MWT, and the number of stops during the 6MWT were noted/calculated.

For subjects 20–40 y old and in the absence of specific local reference values, the predicted 6MWD was calculated using the Italian reference values.[46] For subjects ≥ 40 y old, the predicted 6MWD was calculated according to local reference values.[35] The 6MWD lower limit of the normal range was calculated by subtracting from the predicted 6MWD value of 89 m.[35]

Dyspnea during the 6MWT was evaluated by the visual analog scale, which allows an easy evaluation of exercise dyspnea.[47] Dyspnea was then quantified from 0 (no breathlessness) to 10 (maximum breathlessness). (For additional information about 6MWD reference values and dyspnea evaluation, see the supplementary materials at http://www.rcjournal.com.)

The following definitions were applied. (1) A 6MWD lower than its lower limit of the normal range was considered a clinically important abnormal value and showed walk intolerance.[34,35] (2) Stopping during the 6MWT was regarded as an intolerance sign.[34,35] (3) A difference in oxyhemoglobin saturation before and after the 6MWT of > 5 points was defined as a clinically important desaturation.[35,48] (4) An ending dyspnea score of > 5/10 (visual analog scale) was considered clinically important and showed walk intolerance.[47,48] (5) An ending heart rate of < 60% predicted was considered a chronotropic insufficiency.[35,46]

Because the 6MWT evaluates the integrated response of the cardiorespiratory and muscular chain,[34] we calculated, only for subjects ≥ 40 y old, the estimated cardiorespiratory and muscular chain age (y)[35]: $140.17 - 0.19 \times$ 6MWD (m) $- 0.43 \times$ weight (kg) $+ 52.92 \times$ height (m).

Description of Narghile

The narghile is a water pipe that is used to smoke a tobacco preparation (flavored or unflavored) burned by charcoal embers; the smoke is cooled by passing through water before being inhaled.[3] The different parts of a narghile are indicated in Figure 1. In Tunisia, tabamel is the most popular tobacco for narghile use,[3,49,50] and one smoked narghile contains an average of 20–30 g of tobacco. (For additional information, see the supplementary materials at http://www.rcjournal.com.)

Statistical Analysis

Expression Modes of Results. Analysis of the variable distribution was performed using the Kolmogorov-Smirnov test. When the distribution was normal and variances were equal, the results were expressed as mean ± SD. Otherwise, the results were expressed as the median (first to third quartile) and frequencies for categorical variables. The Student *t* test was used to compare measured versus predicted data (spirometric and 6MWD values), resting versus ending 6MWT data, and chronological versus estimated ages.

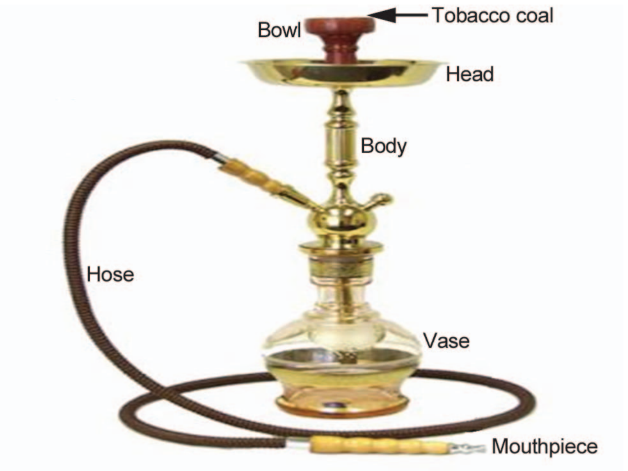

Fig. 1. Parts of the narghile.

Univariate and Multiple Regression Analysis (Influencing Factors). The dependent variable (6MWD) was normally distributed. The *t* test was used to evaluate the associations between the measured 6MWD and the categorical variables (0, no; 1, yes) for cough, sputum, dyspnea (Modified Medical Research Council dyspnea scale), history of abdominal surgery, sedentary or obesity status, and obstructive ventilatory defect (0, unfavorable; 1, favorable) for socioeconomic level and (0, low; 1, high) for educational level. Pearson product-moment correlation coefficients (r) and the determination coefficient (r^2) were used to evaluate the associations between the 6MWD and continuous measures: physical activity scores, narghile use (narghile-years and kg), age (y), weight (kg), height (m), BMI (kg/m^2), FEV_1 (L), FVC (L), FEV_1/FVC (absolute value), peak expiratory flow (L/s), maximum mid-expiratory flow (L/s), resting dyspnea (visual analog scale), resting heart rate (beats/min), resting SBP (mm Hg), DBP_{rest} (mm Hg), and resting oxyhemoglobin saturation (%). The linearity of the association between the 6MWD and the continuous measures was checked graphically by plotting each regressor against the 6MWD. Only significantly and linearly associated variables were entered into the model. A linear regression model was used to evaluate the independent variables explaining the variance in the 6MWD. Candidate variables were stepped into the model with a stepwise selection method. To determine entry and removal from the model, significance levels of .15 and .05, respectively, were used. No colinearity between predictors was detected with variance inflation factors.

Comparison of ENS Subgroup Versus HNS Data. The *t* test and chi-square test were used to compare quantitative data and percentages, respectively. A significance threshold of 5% was retained. Data acquisition and processing was performed using Statistica Kernel 6 (StatSoft, Tulsa, Oklahoma).

Results

ENS Group: Non-Inclusion Criteria and Clinical and Anthropometric Characteristics

An initial sample of 82 volunteer adults was examined. Non-inclusion criteria were found for 12 subjects. (See the supplementary materials at http://www.rcjournal.com.)

Table 1 presents the characteristics of the 70 ENS. Twenty percent, 23%, and 31% of the ENS had dyspnea, chronic cough (mean ± SD duration of 4 ± 2 y), and chronic sputum (mean ± SD duration of 4 ± 3 y), respectively. The majority of the ENS had a high school level of education (82%) and a favorable socioeconomic level (67%). One fourth of the ENS were obese and/or sedentary. In addition, 4% of the ENS with diabetes mellitus and/or dyslipidemia (duration range of 2–5 y) were medically treated. The minimum-maximum age, weight, height, BMI, and narghile use (narghile-years and kg) were 20–60 y old, 54–156 kg, 1.54–1.90 m, 20–50 kg/m^2, and 5–145 narghile-years and 46–1,323 kg, respectively.

The narghile use of the 70 ENS according to 10-y age ranges is shown in Figure 2A. A small percentage of ENS smokers 50–60 y old (15%) are included. The 6MWD of the 70 ENS according to narghile use ranges is shown in Figure 2B. A small percentage of the ENS with > 60 narghile-year history (7%) are included.

ENS Group: Evaluation of Deficiency and Spirometric Profile

The spirometric data of the 70 ENS (expressed in absolute values and as % predicted) are presented in Table 1. The measured FEV_1, FVC, and maximum mid-expiratory flow were significantly lower than the predicted values. In addition, 10%, 4%, and 35% of the ENS had FEV_1 less than the lower limit of the normal range, a large-airway obstructive ventilatory defect, and a small-airway obstructive ventilatory defect, respectively. The mean ± SD of the estimated lung age was significantly higher than that of the chronological lung age (44 ± 3 vs 35 ± 11 y, respectively, $P = .01$).

ENS Group: Evaluation of Incapacity

Comparison of the 6MWT Data. Table 2 presents the 6MWT data of the 70 ENS. Compared with the resting data, there was a significant increase in the ending heart rate, SBP, DBP, and dyspnea. Oxyhemoglobin saturation was not significantly changed. The measured 6MWD was not significantly different from the predicted 6MWD (mean ± SD [minimum-maximum] of 693 ± 73 m (403–837 m) versus 101 ± 14% predicted (64–125% predicted), $P = .79$).

6MWT Profile. No one discontinued the walk or required a rest during the walk. Three percent showed a clinically important desaturation, 9% expressed clinically important ending dyspnea scores, 20% had an abnormal 6MWD, and 34% had a chronotropic insufficiency.

Cardiorespiratory and Muscular Chain Age. The cardiorespiratory and muscular chain estimated age of the 25 ENS > 40 y old was significantly higher than the chronological age (65 ± 12 vs 47 ± 6 y, respectively, $P < .001$).

Factors Influencing the 6MWD. Univariate analysis of the 6MWD and ENS data is shown in Table 3. Among the categorical variables, only the sedentary and obesity status significantly affected the 6MWD. The 6MWD significantly correlated with the following continuous variables: narghile use (narghile-years and kg), physical activity score, age, weight, BMI, FEV_1, FVC, peak expiratory flow, maximum mid-expiratory flow, resting SBP, resting DBP, and resting oxyhemoglobin saturation. The independent factors included in the 6MWD forward linear stepwise multiple regressions are listed in Table 4. BMI, FEV_1 (L), and narghile use (narghile-years) together seem to explain 38% of the 6MWD variability. Figure 3 presents the scatter plot for the 6MWD and narghile use. Heavy ENS had the lowest 6MWD.

Characteristics of ENS Distributed According to the 6MWD (Normal vs Abnormal). Compared with the ENS with a normal 6MWD ($n = 56$, 6MWD mean ± SD of 106 ± 10% predicted), the ENS with an abnormal 6MWD ($n = 14$, 6MWD mean ± SD of 81 ± 6% predicted) had heavier narghile use (55 ± 44 vs 19 ± 16 narghile-years, $P < .001$); had lower physically active scores (12 ± 6 vs 17 ± 7, $P = .04$); were older (45 ± 7 vs 32 ± 10 y, $P < .001$); had a higher BMI (30 ± 6 vs 26 ± 4 kg/m^2, $P = .02$); showed a marked decline in spirometric data (eg, FEV_1 of 84 ± 14 vs 94 ± 11% predicted, $P = .004$); had higher resting heart rates (42 ± 6 vs 39 ± 5% predicted, $P = .04$), resting SBP (133 ± 10 vs 124 ± 12 mm Hg, $P = .009$), and resting DBP (85 ± 9 vs 78 ± 10 mm Hg, $P = .01$); and had lower resting oxyhemoglobin saturation (97 ± 4 vs 98 ± 1%, $P = .03$).

Comparison of the 40–60-y-Old ENS Subgroup Versus the HNS Group

Table 5 presents the characteristics of the subgroup of ENS 40–60 y old ($n = 25$) and the group of HNS subjects

Table 1. Characteristics of the Exclusive Narghile Smokers

Clinical and Sociodemographic Characteristics			Values, n (%)
History of abdominal surgery			11 (15)
Diabetes mellitus			3 (4)
History of dyslipidemia			3 (4)
History of angina pectoris			1 (1)
Coughing (4–6 times/d, 4–6 times/wk)			16 (23)
Spitting (2 times/d, ≥ 4 times/wk)			22 (31)
Dyspnea (Modified Medical Research Council scale)			14 (20)
Obstructive sleep apnea			2 (2)
Favorable socioeconomic level			47 (67)
High educational level			58 (82)
Sedentary			14 (20)
Ideal weight			25 (36)
Overweight			30 (43)
Moderate obesity			12 (17)
Important obesity			1 (1)
Morbid obesity			2 (2)
All classes of obesity			15 (21)
Anthropometric Characteristics, Narghile Use, and Physical Activity Scores			
Age, median (first to third quartile), y			32 (26–43)
Weight, median (first to third quartile), kg			80 (70–87)
Leisure activity score, median (first to third quartile)			4 (3–6)
Narghile quantity use, median (first to third quartile), narghile-years			17 (8–32)
Narghile quantity use, median (first to third quartile), kg			151 (73–292)
Height, mean ± SD, m			1.73 ± 0.06
Body mass index, mean ± SD, kg/m^2			27 ± 5
Daily activity score, mean ± SD			1 ± 1
Sporting activity score, mean ± SD			9 ± 6
Physical Activity Score, Mean ± SD			16 ± 7
Spirometric Data			
	Absolute Value, Mean ± SD	% Predicted, Mean ± SD	P
FEV$_1$, L	4.02 ± 0.71	92 ± 12	< .001*
FVC, L	4.73 ± 0.87	94 ± 13	.01*
FEV$_1$/FVC	0.85 ± 0.07	104 ± 8	.06
Peak expiratory flow, L/s	8.82 ± 1.87	100 ± 20	.97
Maximum mid-expiratory flow, L/s	4.54 ± 1.19	78 ± 19	< .001*
Spirometric Profile			
			Values, n (%)
FEV$_1$ lower than the lower limit of the normal range			7 (10)
Large-airway obstructive ventilatory defect			3 (4)
Small-airway obstructive ventilatory defect			25 (35)

n = 70.
* Student t test: absolute value versus % predicted

40–60 y old (n = 53). In summary, compared with the HNS group, the ENS subgroup had significantly lower scores of sporting, leisure, and physical activities; lower ending heart rate, ending SBP, resting DBP, resting oxyhemoglobin saturation, and 6MWD; higher BMI, resting and ending dyspnea scores, resting heart rate, and ending DBP; higher percentages of subjects with low educational levels or sedentary status; and higher estimated cardiorespiratory and muscular chain age (69 ± 11 vs 51 ± 11 y, $P < .001$ and $P < .05$, respectively). It is important to note

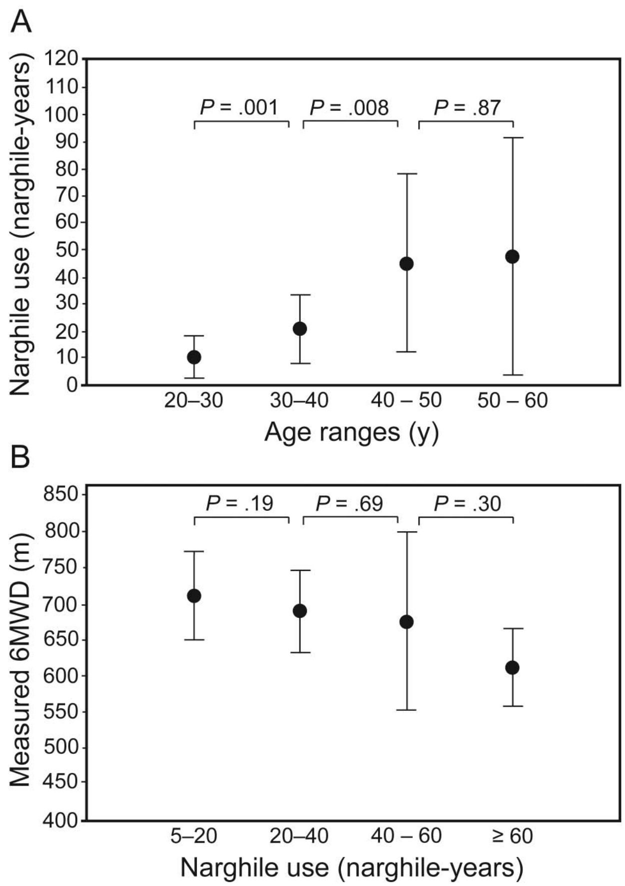

Fig. 2. Data about narghile use. A: Narghile use (expressed in narghile-years) in subgroups of exclusive narghile smokers according to age range. B: Measured 6-min walk distance (6MWD) of subgroups of exclusive narghile smokers according to narghile-years. Data are shown as mean ± SD.

that no significant statistical difference was found in the spirometric data between the 2 groups.

Discussion

The main results of the present study involving 70 ENS are that narghile use may play a role in reducing the submaximal aerobic capacity and accelerates the aging of the cardiorespiratory and muscular chain. In addition to quantity of narghile use, a high BMI and a low FEV_1 were shown to accelerate the 6MWD decline in the ENS group. Compared with HNS subjects, the ENS subgroup had a significantly lower 6MWD (87 ± 9 vs 98 ± 7% predicted, $P < .001$). This is a serious argument for encouraging narghile use cessation.

Methodology

For a discussion of the characteristics of the 2 published studies[10,25] reporting exercise data in ENS, see the supplementary materials at http://www.rcjournal.com.

Type of Study. This cross-sectional study was economical and easy to perform. It required less time than a longitudinal study and provided much useful information. We decided to compare the spirometry and 6MWT values of a subgroup of ENS with those obtained in another group of age-matched HNS. However, it was desirable to include another group of exclusive cigarette smokers[10] and/or a validation group.[25]

ENS Sample Size. In a previous study analyzing spirometric deficiency,[16] 110 ENS were included. In the present study, in addition to deficiency, incapacity was evaluated in a field test. This required more time and explains the smaller sample size ($n = 70$). However, the sample size in the present study, calculated using a predictive equation[36] based on the percentage (13%) of ENS with abnormal FEV_1,[16] seemed satisfactory. This percentage is similar to that found in the present study (10%). In addition, the ENS sample size was larger than that used in the 2 studies aiming to evaluate the incapacity of ENS ($n = 22$[10] $n = 24$[25]). (See the supplementary materials at http://www.rcjournal.com.)

Questionnaires and Inclusion and Non-Inclusion Criteria. No standardized medical questionnaire was used in the other 2 studies.[10,25] (See the supplementary materials at http://www.rcjournal.com.) Medical questions that reduced the risk of errors were asked in face-to-face. Physical activity was assessed by a standardized questionnaire.[39] The last is reproducible, and its score is positively correlated with the extent of 24 h of physical activity quantified by using a pedometer.[39]

The applied non-inclusion criteria are in line with those reported for such studies. (See the supplementary materials at http://www.rcjournal.com.) The high percentage of obese ENS included in the present study (21%) is similar to that reported by Shafique et al.[9] In addition, it is known that lung alteration occurs only in cases of significant obesity without recognized pulmonary disease.[51] In the present study, only 3 ENS presented significant obesity; they were not excluded. It is possible that other criteria not assessed in this study, such as occupational exposure and type of heating used in the home,[37] could have influenced the present results. However, when answering the medical questionnaire, no ENS reported being followed by an occupational physician.

Some precautions were taken during this study. The 6MWT contraindications, which increase the risk of arrhythmia or collapse, were applied as non-inclusion criteria.[34] To avoid misinterpretation, only male and currently clinically stable ENS were included. As in the other 2 studies,[10,25] females were not included, despite the fact that the narghile phenomenon is affecting more and more women (69% of Kuwait females are ENS[52]). (See the sup-

Table 2. 6-Min Walk Test Data for Exclusive Narghile Smokers

	Resting	Ending	*P*
Heart rate, mean ± SD, beats/min	73 ± 9	121 ± 22	< .001*
Heart rate, mean ± SD, % predicted	40 ± 5	66 ± 12	< .001*
Oxyhemoglobin saturation, median (first to third quartile), %	98 (97–98)	98 (97–98)	.59
Systolic blood pressure, median (first to third quartile), mm Hg	120 (120–130)	150 (140–160)	< .001*
Diastolic blood pressure, median (first to third quartile), mm Hg	80 (70–85)	90 (80–100)	< .001*
Dyspnea score (visual analog scale), median (first to third quartile)	0 (0–0)	2 (1–3)	< .001*
6MWD, mean ± SD, m	693 ± 73		
6MWD, mean ± SD, % predicted	101 ± 14		.77†

n = 70.
* Student *t* test: resting versus ending
† Student *t* test: 6-min walk distance (6MWD; m) versus 6MWD (% predicted)

plementary materials at http://www.rcjournal.com.) In fact, their inclusion could lead to a diagnosis bias for COPD, for example.[53] As the average age of initiation into narghile use is 19 ± 5 y[54] and as narghile use of > 5 narghile-years[10] was set as an inclusion criterion, only ENS > 20 y old were included. However, this narghile phenomenon affects more and more teenagers.[49,50] As life expectancy in healthy Tunisians was 61 y in 2003, we were unlikely to find ENS over 60 y old who were free of comorbidity and clinically stable. This explains the application of 60 y as an upper age limit. The mean age of ENS (35 y) was intermediate between those of the other 2 studies (20 y[25] and 45 y[10]). To avoid potential confounding effects, smokers with a history of asthma were not included.[55] Some other criteria were applied by Hawari et al,[25] such as abnormal hemoglobin (< 12.5 g/dL), resting oxyhemoglobin saturation < 96%, and fever. (See the supplementary materials at http://www.rcjournal.com.)

Narghile Tobacco Types. Information about the type of tobacco used was lacking in previous studies.[10,25] The tobacco used for a narghile weighs between 20 and 30 g[3,16] (and not 10–25 g as stated by Koubaa et al[10]) and is available in 3 main types[1]: tabamel, tombak, and jurak. Tabamel (Latin tob for tobacco and mel for honey) or moassel (also maasel; sweet, mostly used in Tunisia[16]) contains 30% tobacco and 70% molasses/honey/glucose syrup plus glycerol and essences. It is much less strong than jurak (nicotine) and is often flavored (apple, strawberry, banana, etc). (For detailed information on tombak and jurak, see the supplementary materials at http://www.rcjournal.com.) Because narghiles are most often smoked in groups in relatively confined areas, such as cafés and tearooms, the actual amount of smoke inhaled is underestimated.[3] In addition, as ENS are in this environment everyday for at least 100 min, they become passive smokers at the same time.[15]

In this study, we chose to evaluate submaximal aerobic capacity using the 6MWT data. (For our justification and for precautions taken during the test, see the supplementary materials at http://www.rcjournal.com.)

Applied Definitions for Spirometry and 6MWT Data. International spirometric definitions (based on 95% CI)[43] and those used in the 6MWT interpretation[34,35] were applied. The estimated cardiorespiratory and muscular chain age was calculated only for subjects ≥ 40 y old ($n = 25$).[35] In fact, application of the Italian 6MWD reference values[46] to this ENS subgroup gave erroneous results.

Study Limitations. Other factors not evaluated in this study may have influenced submaximal aerobic capacity: morphological data (lower limb length, quadriceps strength, muscle biopsy data), biological data (oxidative stress, inflammation, apoptosis, anemia), functional respiratory data (lung volumes, maximum inspiratory and expiratory pressures), blood gas (presence of hypoxemia), diffusion capacity of the alveolar-capillary membrane, measurement of carboxyhemoglobin levels in the blood, and echocardiography data. (For additional information regarding methodology, see the supplementary materials at http://www.rcjournal.com.)

Outcome

Evaluation of Deficiency and Spirometric Profile. The spirometric profile of ENS particularly deteriorated in the presence of small-airway obstructive ventilatory defects and acceleration in lung aging. This chronic harmful effect, similar to that induced by cigarette smoking, was described previously in several studies.[7,10,13-22]

Evaluation of Incapacity. Studies on maximal and submaximal aerobic capacities of ENS are rare. (See the supplementary materials at http://www.rcjournal.com.) Kou-

Table 3. Univariate Analysis of 6-Min Walk Distance and Qualitative or Quantitative Variables

Qualitative Variables	Code	Mean ± SD	P
Cough (4–6 times/d, 4–6 times/wk)	Yes ($n = 16$)	689 ± 72	.40
	No ($n = 54$)	707 ± 76	
Sputum (2 times/d, ≥ 4 times/wk)	Yes ($n = 22$)	688 ± 77	.39
	No ($n = 48$)	705 ± 62	
Dyspnea (Modified Medical Research Council scale)	Yes ($n = 14$)	679 ± 67	.06
	No ($n = 56$)	699 ± 74	
History of abdominal surgery	Yes ($n = 11$)	699 ± 51	.76
	No ($n = 59$)	692 ± 77	
Socioeconomic level	Unfavorable ($n = 23$)	692 ± 45	.93
	Favorable ($n = 47$)	694 ± 84	
Educational level	Low ($n = 12$)	659 ± 73	.06
	High ($n = 58$)	701 ± 71	
Sedentary status	Sedentary ($n = 14$)	646 ± 89	.005*
	Active ($n = 56$)	705 ± 64	
Obesity	Yes ($n = 15$)	653 ± 94	.01*
	No ($n = 55$)	704 ± 62	
Large/small-airway obstructive ventilatory defects	Yes ($n = 28$)	691 ± 66	.85
	No ($n = 42$)	695 ± 77	
Quantitative Variables	**Unit**	**Correlation Coefficient**	**P**
Quantity of tabamel used	Narghile-years	−0.36	.002†
Physical activity score		0.33	.004†
Age	y	−0.38	< .001†
Height	m	0.10	.39
Weight	kg	−0.48	< .001†
Body mass index	kg/m^2	−0.54	< .001†
FEV_1	L	0.51	< .001†
FVC	L	0.42	< .001†
Peak expiratory flow	L/s	0.45	< .001†
Maximum mid-expiratory flow	L/s	0.27	.02†
FEV_1/FVC	Absolute value	0.15	.22
Resting dyspnea	Visual analog scale	−0.12	.38
Resting heart rate		−0.18	.13
Resting systolic blood pressure	mm Hg	−0.35	.002†
Resting diastolic blood pressure	mm Hg	−0.30	.01†
Resting oxyhemoglobin saturation	%	−0.48	< .001†

$n = 70$ exclusive narghile smokers.
* Student t test for qualitative variables
† Correlation coefficient for quantitative variables

Table 4. Independent Factors Included in the 6-Min Walk Distance Forward Linear Stepwise Multiple Regressions

Independent Factors	Non-Standardized Regression Coefficient	Cumulated Determination Coefficient	P
Constant	742.6346		<.001
Body mass index, kg/m^2	−5.1969	0.2879	<.001
FEV_1, L	25.2326	0.3557	.03
Narghile use, narghile-years	−0.4397	0.3796	.04

$n = 70$ exclusive narghile smokers. 6-min walk distance (m) = 742.63 − 5.20 × body mass index + 25.23 × FEV_1 − 0.44 × narghile use.

baa et al[10] found that an ENS group had a significantly lower maximal $\dot{V}_{O_2}$ and lower maximum aerobic speed compared with an exclusive cigarette smoker group. Hawari et al[25] found that a single session of narghile smoking induced a significant decrease in $\dot{V}_{O_2}$.

The submaximal aerobic capacity of ENS seemed to deteriorate. Indeed, compared with the HNS group, the subgroup of ENS had a significantly lower 6MWD by 102 m (see Table 5). In addition, almost one fifth of the ENS had an abnormal 6MWD. Similarly, there were signs of walking intolerance: 3% and 9% of the ENS showed a clinically important desaturation and clinically important

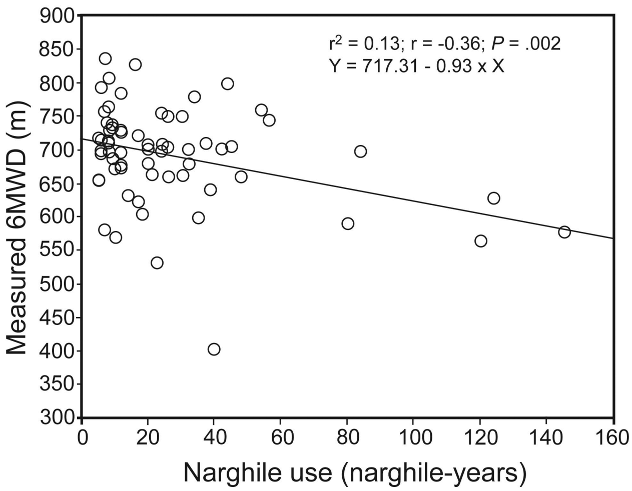

Fig. 3. Scatter plot of 6-min walk distance (6MWD) and narghile use (narghile-years) of 70 exclusive narghile smokers.

ending dyspnea scores, respectively. Another key outcome of the present study is that narghile smoking accelerated cardiorespiratory and muscle chain aging. This is an unwavering argument to motivate ENS to stop smoking. Thirty-four percent of the ENS had an impaired chronotropic heart response. This may reflect the impact of narghile smoking on the activity of the sinus node during walking.[26] To the best of our knowledge, the present study is the first to determine such chronic effects of narghile use on submaximal aerobic capacity.

How Can We Explain the Impairment of ENS Submaximal Aerobic Capacity?

The alteration of submaximal aerobic capacity was more pronounced in ENS with a higher BMI, a lower initial FEV_1, and/or heavier smoking. These factors are analyzed below.

Effect of BMI. Obesity, especially the morbid type, is predictive of 6MWD decline.[34,35] In the present study, as in others conducted with healthy subjects,[35] the 6MWD decreased by ~5 m when the BMI increased by 1 unit. Moreover, compared with the HNS subgroup (see Table 5), the ENS subgroup had a significantly higher BMI (27 ± 3 vs 30 ± 5 kg/m^2, respectively), with a significantly fewer number of subjects at ideal weight (17 vs 4%, respectively). Similarly, the ENS group with an abnormal 6MWD had a significantly higher BMI compared with the ENS group with a normal 6MWD (30 ± 6 vs 26 ± 4 kg/m^2, respectively). The present study suggests that the association narghile use-obesity accelerates 6MWD decline. This result is an important argument to encourage ENS to start a diet and/or regular exercise.

Effects of Resting Spirometric Data. Spirometric data are predictors of 6MWD.[34,35] Indeed, the 6MWD of healthy North Africans decreased by ~12.5 m when the FEV_1 decreased by 1 L.[35] The present study suggests that the alteration of the resting spirometric data observed in the ENS doubled the 6MWD decline, which was ~25 m. Moreover, the ENS group with an abnormal 6MWD had a significantly lower FEV_1 compared with the ENS group with a normal 6MWD (84 ± 14 vs 94 ± 11% predicted, respectively). The alteration of the initial spirometric function limits breathing reserve,[48] and thus, the lungs may be a factor limiting the 6MWD.[48]

Effect of Quantity of Tobacco Use. A higher quantity of tobacco used resulted in a lower 6MWD (see Fig. 3). Similarly, the ENS with an abnormal 6MWD were significantly more engaged in narghile use compared with the ENS with a normal 6MWD (55 ± 44 vs 19 ± 16 narghile-years, respectively). This original result, part of a more general phenomenon, can be explained by the negative consequences of narghile use on cardiorespiratory and muscle functions.

First, it is well established that acute narghile use and chronic narghile use affect resting breathing frequency and lung function data, alter pulmonary epithelial permeability, and accelerate lung aging.[7,10,13-21,25,29] An example of an acute effect is that a single 30-min session of narghile smoking induced a significant increase in breathing frequency of 2 ± 2 breaths/min.[29] An example of a chronic effect is that of 110 ENS with a > 1 narghile-year history, 14% had small-airway obstructive ventilatory defects, and 6% had large-airway obstructive ventilatory defects with a significantly higher estimated lung age compared with chronological lung age (47 ± 18 vs 34 ± 10 y). The present study confirms these findings because the estimated lung age of the ENS group was significantly higher than the chronological lung age, and 35%, 9%, and 3% of the ENS had small-airway obstructive ventilatory defects, clinically important ending dyspnea scores, and a clinically important desaturation, respectively. Similarly, the ENS group with an abnormal 6MWD had lower respiratory data and lower resting oxyhemoglobin saturation compared with the ENS group with an normal 6MWD. In addition, compared with the HNS group, the ENS subgroup 40–60 y old had significantly higher resting and ending dyspnea scores and significantly lower resting oxyhemoglobin saturation (see Table 5).

Second, chronic narghile use and acute narghile use alter the resting cardiac function assessed by heart rate and blood pressure.[10,25-31] An example of an acute effect is that a single 30-min session of narghile smoking (10 g of double apple-flavored tabamel) by 45 volunteers induced a significant increase in SBP (from 120 ± 12 to 132 ± 18 mm Hg), DBP (from 75 ± 8 to 83 ± 13 mm Hg),

Table 5. Comparison of Data From an ENS Subgroup and a Group of HNS Subjects

	ENS (n = 25)	HNS (n = 53)	P
Quantitative variables, mean ± SD			
Quantity of narghile use, narghile-years	46 ± 37	0 ± 0	< .001
Daily activity	1.29 ± 0.65	1.43 ± 0.59	.37
Sporting activity	3.25 ± 4.64	7.75 ± 5.90	< .001*
Leisure activity	2.51 ± 3.31	5.05 ± 2.77	< .001*
Physical activity	7.05 ± 5.62	14.23 ± 6.73	< .001*
Age, y	47 ± 6	49 ± 5	.09
Height, m	1.71 ± 0.06	1.73 ± 0.05	.09
Weight, kg	87 ± 18	82 ± 8	.07
Body mass index, kg/m^2	30 ± 5	27 ± 3	.01*
FEV_1, L	3.46 ± 0.63	3.54 ± 0.62	.61
FEV_1, % predicted	99 ± 15	100 ± 12	.76
FVC, L	4.18 ± 0.76	4.19 ± 0.74	.92
FVC, % predicted	97 ± 15	96 ± 12	.62
Peak expiratory flow, L/s	7.74 ± 1.85	8.47 ± 1.70	.09
Peak expiratory flow, % predicted	90 ± 21	98 ± 19	.10
Maximum mid-expiratory flow, L/s	3.90 ± 1.08	4.20 ± 1.23	.28
Maximum mid-expiratory flow, % predicted	98 ± 28	106 ± 28	.24
FEV_1/FVC, absolute value	0.83 ± 0.05	0.85 ± 0.06	.28
Resting dyspnea, visual analog scale	0.1 ± 0.3	0.0 ± 0.0	.008*
Ending dyspnea, visual analog scale	2.3 ± 1.4	1.0 ± 0.8	< .001*
Resting heart rate, beats/min	82 ± 11	74 ± 9	< .001*
Resting heart rate, % predicted	47 ± 6	42 ± 5	< .001*
Ending heart rate, beats/min	120 ± 18	154 ± 19	< .001*
Ending heart rate, % predicted	69 ± 10	88 ± 11	< .001*
Resting SBP, mm Hg	132 ± 13	129 ± 18	.44
Ending SBP, mm Hg	157 ± 19	172 ± 32	.03*
Resting DBP, mm Hg	85 ± 10	78 ± 16	.004*
Ending DBP, mm Hg	95 ± 15	77 ± 20	< .001*
Resting oxyhemoglobin saturation, %	97 ± 3	98 ± 1	.04*
Ending oxyhemoglobin saturation, %	97 ± 4	97 ± 1	.48
6MWD, m	654 ± 78	756 ± 68	< .001*
6MWD, % predicted	87 ± 9	98 ± 7	< .001*
Qualitative variables, n (%)			
Unfavorable socioeconomic level	10 (40)	30 (56)	.09
Low educational level	7 (28)	2 (4)	< .001†
Sedentary	17 (68)	20 (37)	.006†
Ideal weight	1 (4)	9 (17)	.05†
Overweight	15 (60)	34 (64)	.36
Moderate obesity	7 (28)	10 (19)	.18
Massive obesity	2 (8)	0 (0)	.02

* Student t test
† chi-square test
ENS = exclusive narghile smokers
HNS = healthy non-smokers
SBP = systolic blood pressure
DBP = diastolic blood pressure
6MWD = 6-min walk distance

and heart rate (from 80 ± 10 to 96 ± 17 beats/min).[31] An example of a chronic effect is that the resting heart rate and resting SBP of the 22 ENS with a > 5 narghile-year history were significantly higher than those of the HNS group (93 ± 4 vs 78 ± 4 beats/min and 141 ± 4 vs 131 ± 3 mm Hg, respectively).[10] Thirty-four percent of the ENS had a chronotropic insufficiency, and the ENS group with an abnormal 6MWD had a significantly higher resting heart rate, resting SBP, and resting DBP compared with the ENS group with a normal 6MWD (42 ± 6 vs

39 ± 5% predicted, 133 ± 10 vs 124 ± 12 mm Hg, and 85 ± 9 vs 78 ± 10 mm Hg, respectively). In addition, the ENS subgroup had a significantly higher resting heart rate and resting DBP compared with the HNS subgroup (see Table 5). The heart rate acceleration and blood pressure increase have harmful effects on submaximal aerobic capacity.[56]

Other Factors Explaining the Submaximal Aerobic Capacity Decline

The aforementioned factors explain 38% of the 6MWD variability, which means that 62% of the variability remains unexplained. What other factors not evaluated in the present study may have affected the 6MWD of the ENS?

We can discuss myopathy as an altering factor of submaximal aerobic capacity: it is likely that the functional, morphological, and metabolic qualities of muscle tissue in ENS are altered. Myopathy could be the result of numerous alterations, with the main ones being sedentary lifestyle, inflammation, apoptosis, oxidative stress, and hypoxia. (See the supplementary materials at http://www.rcjournal.com.)

Conclusion

Exclusive narghile use may cause an alteration in submaximal aerobic capacity, an adverse effect integrated into a more general phenomenon. To improve submaximal aerobic capacity, a key determinant of quality of life, the results of the present study suggest that a pulmonary rehabilitation program (physical training, weight reduction, narghile use cessation) is an excellent axis to follow. Developing pulmonary rehabilitation policies and measuring their impact in an ENS population are strongly recommended.

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