Introduction
More than ever the Menthol theme is a topical question. As menthol's cooling effect might affect puffing and smoke inhalation, possible adverse effects of cigarette mentholization have been suggested. As example, mentholation of the cigarette may increase smoke exposure by affecting smoking behavior and topography. However only few publications in this controversial topic, especially including smoking topography are available in the public domain.1

Smoking topography (defined as the “puffing behavior” including human puff volume, duration and frequency) although not considered as today a well-known technique. However, artificial laboratory testing used for topography records may disturb the smoker and therefore may lead to a bias between laboratory and natural conditions.2

Human Smoker Yield (amount of mainstream smoke constituent exiting the cigarette into the mouth when a given human smoker the cigarette) can be measured by duplication of the whole human smoking profile or estimated by cigarette filter analysis.3 The basic principle is that the amount of tar and nicotine deposited on the filter is proportional to the amount of tar and nicotine that emerges from the cigarette.

We closely applied this principle to look at the smoking behavior of regular menthol smokers. Therefore a cross-sectional study in regular Caucasian smokers of American blended mentholated and non-mentholated cigarettes was carried out. As two brands with the same specification (tobacco blend and design) with and without menthol were not commercially available, we selected two products having similar tar (12 mg ISO) and nicotine (0.7 mg ISO) levels. The purpose of this study was to determine whether these two groups exhibit differences in smoking profile and biomarkers of exposure.

Methods

- Volunteers externally recruited, given written consent and provided with remuneration for the work. Pulmonary X-ray performed to check no chest dysfunction.
- 64 female smokers on their regular brand (32 menthol vs. non-menthol smokers). Ages 22-58, smoking at least 10 cigar/day of their brand for at least 2 years the product under study.
- Smoking behavior & Topography
  - Subjects made familiar with the procedure and practiced using the cigarette holder in the lab.
  - Puffing was performed in the lab throughout the smoking topography "sessions" on the first cigarettes of the day. Human Smoking Profiles recorded on Full Analyzer (AFIC D 66, Sodin, France).
  - Inhaled verified by measuring breath CO (Micro Smokerlyser, Bedfont, UK).
- Human Smoker Yield
  - NI yield estimated by cigarette fiber analysis. Buds collected from the nose the day before first laboratory smoking behavior measurements.
  - Calibration curves (Tar, Nicotine yields vs. Absorbance per tip) built after duplication of each individual human smoking profiles (EFC D 67, Sodin). But buds analyses: - Absorbance of the isopropanol extract of the filter at 444 nm (spectrometer UVIKON, Kontron Instruments, Tegimenta AG, Switzerland).
  - Tar between Lab and natural condition: ratio of filter absorbance in this two environmental conditions.

- Biomarker levels and creatinine
  - from 24H urine samples: Nicotine and metabolites evaluated by colorimetric assay (Barlow total).

- Standardized data (STANPASCHS, Muco, Molinier) & Battled tests for each smoker group and test between groups. In the Tables below, green lines connect values that were statistically significantly different at the p<0.05 level.

Results

- As a proxy in the estimate of the volume of the smoke in the lung we calculated:

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  \text{Volume of smoke} = (15 - 6.12/1.08, 6.12/1.08 - 3.0, 7.15/1.08 - 3.0) \times \text{body weight (kg)}
  \]

Cigarettes
- Commercial products on the French market
  - Regular size, American blend, Acetate filter with the following design:

- Regular size: 89 mm, filter length 25 mm, filter diameter 7 mm, 13 filter rings.
- American blend: 89 mm, filter length 25 mm, filter diameter 7 mm, 13 filter rings.
- Acetate filter: 89 mm, filter length 25 mm, filter diameter 7 mm, 13 filter rings.

Discussion
- The Smoking Topography measurements, showed significant differences between the two groups of smokers. Higher values (p<0.05) of average puff volume, average flow rate, total smoking duration and total volume of smoke provided for smokers of non-menthol cigarettes. No substantive differences in puff number, puff interval and puff duration were found.
- Although we confirmed a bias (Natural/Lab) due to the topography device, no significant differences were found between groups. But length (Nat vs. Lab) were comparable and without significant difference between the two groups.
- Significant fewer cigarettes were smoked the day of the study by menthol smokers (18.0 vs. 14.2 cigs/day) even though the two populations were selected as close as possible (including the self-reported daily consumption). Nevertheless, no significant impacts on biomarker of exposure were observed (normalized by 24H urinary creatinine as well).
- The estimated daily inhaled CO expressed in mg/day was significantly higher for the menthol product. Although the Total Volume of smoke is weaker for menthol smokers, further parameters are to be taken into account:
  - the selected Menthol brand is characterized by both a higher CO yield (15.3 vs. 12.7 mg/cig) and a higher CO per puff (2.0 vs. 1.5 mg/puff)
  - under ISO.
- The daily consumption for Menthol Smokers was higher.

Conclusions
- No difference or less intense puffing parameters for Menthol Smokers than for Non-menthol Smokers.
- Smokers of menthol and non-menthol cigarettes exhibit identical levels of biomarkers of exposure (carboxyhemoglobin and nicotine metabolites measurement).
- Human Smoker Yields per cig. (calculated using butts from natural smoking conditions) were lower for the Menthol Smokers vs. Non-menthol Smokers: 52%, 36% and 11% for tar, nicotine and CO, respectively.
- Estimating the volume of the smoke in the lung, we confirmed no differences in daily inhaled nicotine between the two groups but a significant higher daily inhaled CO for Menthol Smokers, partially explained by differences from cigarette design.

References
1. Vink, J. D. A review and assessment of menthol employed as a cigarette flavoring ingredient. Food and Chemical Toxicology 46-51, 505-514, 2008.
7. The basic principle is that the amount of ‘tar’ and nicotine deposited on the filter is proportional to the amount of tar and nicotine that emerges from the cigarette. This study was to determine whether these two groups exhibit differences in smoking profile and biomarkers of exposure.
8. Human Smoker Yield (amount of mainstream smoke constituent exiting the cigarette into the mouth when a given human smoker the cigarette) can be measured by duplication of the whole human smoking profile or estimated by cigarette filter analysis. The basic principle is that the amount of tar and nicotine deposited on the filter is proportional to the amount of tar and nicotine that emerges from the cigarette.

* p< 0.05
Non-menthol | Menthol Smokers

- Volume
- Flow
- Duration
- COHb
- Urine output
- COYield
- Cotinine
- Bias
- Butt length
- Relative Butt length Lab vs Natural
- Daily consumption

*Denotes consumption in 24h home setting