Comparison Of Regular Smokers Of Menthol And Non-menthol Cigarettes On Smoking Profile And Exposure

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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 mentholation 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 constraint-free is today a well-known technique. However artificial laboratory setting 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 smokes 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 filter.

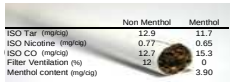
We closely applied this principle to look at the smoking behavior of regular menthol smokers.

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.

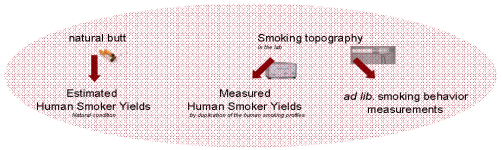
The purpose of this study was to determine whether these two groups exhibit differences in smoking profile and biomarkers of exposure.

Cigarettes

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



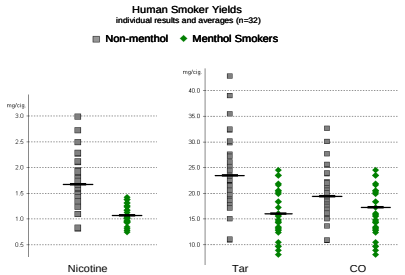
	Non Menthol	Menthol
ISO Tar (mg/cig)	12.9	11.7
ISO Nicotine (mg/cig)	0.77	0.65
ISO CO (mg/cig)	12.7	15.3
Filter Ventilation (%)	12	0
Menthol content (mg/cig)		3.90



Methods

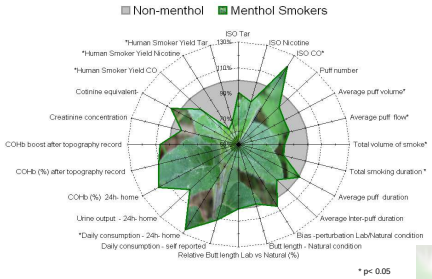
- Volunteers externally recruited, given written consent and provided with remuneration for the work. Pulmonary X-ray performed to check no chest dysfunction.
- 64 female smokers on their regular brand (32:32 menthol *vs.* non-menthol smokers).
  Ages 22-58, smoking at least 10 cig/day of their brand for at least 2 years the product under study.
- Smoking behavior & Topography
  - Subjects made familiar with the procedure and the equipment and practiced using the cigarette holder in the lab.
  - Smoking behavior measurement performed in the lab throughout the smoking topography "ad libitum" on the first cigarette of the day. Human Smoking Profiles recorded on the Puff Analyzer (AFC D-80, Sodim, France)
  - Inhalation verified by measuring breath CO (MicroII Smokerlyser, Bedfont, UK).
- Human Smoker Yield
  - HS Yield estimated by cigarette filter analysis. Butts collected from home (the day before their laboratory smoking behavior measurements).
  - Calibration curves (Tar, Nicotine yields *vs.* Absorbance per tip) built after duplication of each individual human smoking profiles (DFC D-87, Sodim).
  - Butt analyses : Absorbance of the isopropanol extract of the filter at 464 nm (spectrometer UVIKON, Kontron Instruments, Tegimenta AG, Switzerland). [4]
  - Bias between Lab & 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).[5]
    Creatinine determined by colorimetric method of Jaffe.
  - COHb (%) indirectly calculated from CO expired after 20s- apnea using Radziszewski Method.[6]
- Statistical analysis (STATGRAPHICS Plus). Kolmogorov & Bartlett tests for each smoker group and t-test between groups. In the Tables below, green lines connect values that were statistically significantly different at the p < 0.05 level.

Results



Average (n=32 per brand)	Non Menthol	Menthol
Human Smoker Yield Nicotine (mg/cig)	1.07	1.07
Human Smoker Yield Tar (mg/cig)	23.5	16.0
Human Smoker Yield CO (mg/cig)	19.4	17.3

- Radar plot constructed by setting the Non-menthol product data to 100% and then normalizing the Menthol product results.



* p< 0.05

- As a proxy in the estimate of the volume of the smoke in the lung[7] we calculated :

$$\text{Estimated daily intake} = \left(\frac{\text{Volume of CO retained by the smoker}}{\text{Volume of CO produced (mouth-end) during the topography record}}\right) \times (\text{daily consumption})$$

$V_{CO\ \text{retained}}\ (ml) = 65.6\ (mL_{smoke}/kg_{smoker}) * \text{Body Weigh t}\ (kg) * 143\ (g_{COHb}/L) * 139\ (mL_{smoke}/g_{COHb}) * \text{COHb}_{boost}\ (\%)$

– Volume of CO retained by the smoker calculated from the COHb boost
– Volume of CO produced by the cigarette smoked according to the duplicated human smoking profile

	Non Menthol	Menthol
estimated daily inhaled smoke CO (mg/day)	164	237
estimated daily inhaled smoke Nic (mg/day)	14.1	14.7

Topography (n=32 per brand)	Non Menthol	Menthol
Puff number	14.3	13.1
Average puff volume (mL)	45.0	39.6
Average puff flow rate (mL/s.)	25	22
Total volume of smoke (mL)	608	506
Total smoking duration (s.)	329	275
Average puff duration (s.)	1.91	1.93
Average inter-puff duration (s.)	25.4	22.6
Bias - Lab/Natural	1.46	1.54
Butt length (mm) -natural condition	31.3	30.7

Exposure (n=32 per brand)	Non Menthol	Menthol
Daily consumption (cig/day) - self reported	15.4	17.1
Daily consumption (cig/day) - 24h- home	14.2	18.0
Urine output (mL) 24h- home	1089	1066
COHb (%) 24h- home	6.12	7.15
Creatinine (mmol./24 h) 24h- home	8.94	8.26
Cotinine equivalent (µmol. cotinine/24 h) 24h- home	64.5	68.6
COHb (%) -after topography record	4.58	5.03
COHb boost (%) -after topography record	1.8	1.9

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. Butt lengths (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 cig./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 : -32%, -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

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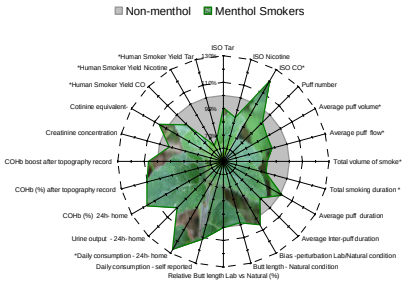
Non-menthol
Menthol Smokers
ISO Tar
ISO Nicotine
ISO CO*
Puff number
Average puff volume*
Average puff flow*
Total volume of smoke*
Total smoking duration *
Average puff duration
Average Inter-puff duration
Bias -perturbation Lab/Natural condition
Butt length - Natural condition
Relative Butt length Lab vs Natural (%)
Daily consumption - self reported
*Daily consumption - 24h- home
Urine output - 24h- home
COHb (%) 24h- home
COHb (%) after topography record
COHb boost after topography record
Creatinine concentration
Cotinine equivalent*
*Human Smoker Yield CO
*Human Smoker Yield Nicotine
*Human Smoker Yield Tar