risk of chronic bronchitis was greater in men than in women for all smoking categories, but no differences in pulmonary function were observed. The excess risk for men did not appear to be due to differences in cigarette consumption. In our own case control series at the Johns Hopkins Medical Institutions, the rate of abacery of forced expiration is greater in men than in women after adjustment for smoking habits and other factors.

In a separate analysis of published data from the Johns Hopkins Medical Institutions, male versus female differences were observed in the configuration of flow volume loops. When compared with women, men have patterns of flow limitation similar to those of heavy smokers when compared with subjects who have never smoked. The pattern of male nonsmokers is similar to female heavy smokers. When comparing rates of decline in pulmonary function in our longitudinal observations, it is apparent that the largest rates of decline are observed in older male and female smokers and in older male nonsmokers.

The explanation for the difference in pattern of pulmonary function deterioration in men versus women is not fully explained. It is probable that the pattern is shifted. This is intriguing because it suggests to us that some protective effect exists in women in the younger years. We have in the past characterized the early male response (abnormal spirometry) as an "airways" response and the female response (abnormal Dco) as a "vascular" response to the effects of smoking. It is possible that hormonal factors play some role in modifying the response.

If, in fact, the pattern of pulmonary function deterioration is different and a protective effect exists; (all worthy of further exploration) then these results have important implications for work evaluating the effects of smoking, environmental factors and occupational exposures on pulmonary function both at an epidemiologic and mechanistic or physiologic level.

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REFERENCES


Effects of Contemporary Filters on Cigarette Smoke*


The Surgeon General’s report linking cigarette smoking to lung cancer led the tobacco industry to develop and market cigarettes with lower tar and nicotine content, and design filters which would further reduce tar and nicotine levels delivered to smokers. Tar and nicotine are carried in the solid, or particulate, phase of cigarette smoke, and deposition is dependent on smoking technique, particle size, and particle concentration. While detailed data are available regarding the chemical content of smoke from contemporary cigarettes, little is known about the physical properties of smoke from contemporary cigarettes, or how filtration alters these properties. This study was undertaken to determine the physical properties of smoke from commercially available cigarettes, and how filtration affects these properties.

METHODS

Particle Analyzer

Aerodynamic properties of smoke aerosol were determined with a single particle aerodynamic relaxation time (SPART) analyzer, which rapidly measures size and concentration of suspended aerosol particles in the .1 to 10 μm size range. The operating characteristics of this instrument have been described in detail elsewhere.

Smoking Device and Dilution System

A brass cylinder was constructed to tightly hold cigarettes, and a brass cone was made to fit tightly over O-rings on the brass cylinder. Puffs were generated by placing the brass cone over the cylinder and activating a switch which delivered a two-second 35 ml puff of filtered air through the cone.

The puff was quickly diluted by a flowing stream of clean air. A shutter valve (Warren E. Collins Co.) was placed between the cigarette holder and diluting air to prevent aspiration of smoke between puffs. Further dilution was achieved by aspirating smoke aliquots from this stream and mixing with clean air for final dilution of 126,000:1. Dilution of this magnitude is necessary to maintain coincidence loss from the SPART below 4%.

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Contemporary cigarettes were purchased from a local vendor and studied on the same day the package was opened. The first four puffs of each cigarette were completely analyzed less than four seconds after generation to measure mass median aerodynamic diameter (MMAD), and concentration (#/ml). Five cigarettes of each brand were tested with and without filters. Percentage of filtration was calculated from the formula: % filtration = 100 - (#/ml with filters / #/ml without filter) / 100. Filter and non-filter results were compared using Student's t test for two means.

## RESULTS

The mass median aerodynamic diameter (MMAD) was similar for all cigarettes and was not altered by passing the smoke through filters. The percentage of filtration ranged from 30 to 57%. Table 1 summarizes these data.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Filtration (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kool, Marlboro</td>
<td>30</td>
<td>&lt;0.025</td>
</tr>
<tr>
<td>Merit</td>
<td>48</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Vantage</td>
<td>48</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Tareyton</td>
<td>54</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Doral II</td>
<td>57</td>
<td>&lt;0.005</td>
</tr>
</tbody>
</table>

Table 1—Particle Size of Cigarette Smoke

<table>
<thead>
<tr>
<th>Brand</th>
<th>With Filter MMAD μM*</th>
<th>Without Filter MMAD μM*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kool, Marlboro</td>
<td>0.45 ± 0.004</td>
<td>0.45 ± 0.004</td>
</tr>
<tr>
<td>Merit</td>
<td>0.43 ± 0.010</td>
<td>0.43 ± 0.010</td>
</tr>
<tr>
<td>Vantage</td>
<td>0.47 ± 0.009</td>
<td>0.47 ± 0.002</td>
</tr>
<tr>
<td>Tareyton</td>
<td>0.51 ± 0.010</td>
<td>0.48 ± 0.003</td>
</tr>
</tbody>
</table>

*Mass Median Aerodynamic Diameter ± Standard Error of the Mean

DISCUSSION

Formation of smoke from a burning cigarette is a complex series of events. The burning tip is 800-900°C. A dense cloud of droplets is formed and entrainment of particles in this size range is a formidable task. The particles are quite small compared to the openings between the fibers of the filters; deposition on the filter is a result of chance collision.

Auerbach et al compared the histologic changes in bronchial epithelium of smokers from 1955-1960 and bronchial epithelium of smokers from 1970-1977, and found reduced evidence of precancerous lesions in the group from 1970-1977 suggesting that reductions of tar and nicotine content and different filters of cigarettes had contributed to the change in the disease pattern. Other epidemiologic studies have indicated a lower death rate from lung cancer among men who smoke low tar cigarettes.

In conclusion, this study shows that contemporary filters reduce concentration of smoke particulate by 47-57%. The size (MMAD) of the particulate is not altered by filtration.

REFERENCES


DISCUSSION

Dr. Brody: Were inorganic particles on the leaves or in the cigarettes of any significance in these studies?

Dr. McCusker: We didn’t identify what particles were present; we just looked at the number.

Dr. Riley: Did you look at the concentration of particulates in the beginning of the smoke compared to what’s at the butt end?

Dr. McCusker: Our preliminary findings suggest very little change in the concentration.

Dr. Rokaw: Do you have any information about the gaseous concentration?

Dr. McCusker: No, we don’t, but other people have shown that there is selective filtration of phenol which has a very bitter taste, and charcoal particles have been shown to further reduce other gaseous concentrations.

Dr. Salvaggio: Whether or not these filters remove particulates, there may still be a problem with passive smoke on the population at large. We have found immunogenic and allergenic material of low molecular weight which is haptenic for lower animal species in cigarette smoke. If you pass air through unlit cigarettes you can still extract this haptenic material.