In summary, these findings suggest that acute exposure to biomass smoke in women with small airways disease or restrictive lung disease is associated with blood deoxygenation, suggesting that in these individuals continued exposures may increase the risk of disease exacerbation.

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Simulated driving performance coupled with driver behaviour can predict the risk of sleepiness-related car accidents

Obstructive sleep apnoea syndrome (OSAS) is associated with the risk of sleepiness-related car accidents and worse driving simulator performances. Nevertheless, driving simulator studies failed to predict the real-world accident risk. Two-thirds of patients with OSAS will never experience a car crash, so that restricting their driving licence because of an OSAS diagnosis is not feasible.1

Our previous studies validated a 30 min monotonous driving scenario (STISIM 300 Driving Simulator, Systems Technology, Hawthorne, California, USA) versus subjective and objective measures of sleepiness in healthy volunteers undergoing a sleep deprivation challenge and in patients with OSAS. Our test disclosed that primary vehicle control parameters (crashes, lane position variability) were the strongest predictors of sleepiness and, potentially, of crash risk.2 We reviewed the driving simulator and sleepiness (maintenance of wakefulness test (MWT) and Epworth sleepiness scale (ESS)) data of 43 men (mean age 53±9 years) with severe OSAS (mean apnoea-hypopnoea index of 55±16/h) together with their responses to a questionnaire on driving history. Clinical features, self-reported behaviour and driving simulation data are reported in table 1, together with statistical comparisons (Mann–Whitney or χ2 tests). Twenty patients (47%) had crashed in the previous 5 years and frequently considered sleepiness the main cause of their accident. They were rated sleepier on the ESS (p=0.038), and trended to crash sooner in the driving simulation (p=0.05), without any other difference. Therefore, the identification of patients at risk based only on laboratory measures is not feasible.

Twenty-eight (65%) patients continued to drive while sleepy (‘risky behaviour’), without differing significantly from patients that stopped driving (‘safe behaviour’). Within the ‘risky behaviour’ subgroup, the 14 (50%) patients with a crash history were sleepier according to the ESS (p=0.019) without reaching statistical significance on the MWT (p=0.062), crashed more frequently (p=0.036) and sooner (p=0.007) at the driving simulation, and showed worse tracking performance (p=0.017) than patients without self-reported crash history. Conversely, there were no differences between subjects with (40%) and without (60%) a crash history in the subgroup of 15 patients that used to stop driving while sleepy.

Previous driving simulator studies were controversial, showing either the presence4 or the absence5 of association between driving simulator performance and accident risk. These conflicting results could reflect the confounding effect of the unexplored

Table 1 Clinical features, self-reported behaviour and driving simulation data of patients with and without crash history and in the subgroups with safe and risky behaviour

<table>
<thead>
<tr>
<th>Clinical features</th>
<th>All patients</th>
<th>Safe behaviour</th>
<th>Risky behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No crash</td>
<td>Crash</td>
<td>p Value</td>
</tr>
<tr>
<td>Age (years)</td>
<td>53.9±7.4</td>
<td>52.6±9.9</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>31.9±5.0</td>
<td>31.9±4.5</td>
<td>NS</td>
</tr>
<tr>
<td>AHI</td>
<td>51.8±15.1</td>
<td>57.8±17.5</td>
<td>NS</td>
</tr>
<tr>
<td>ESS score</td>
<td>9.2±4.0</td>
<td>12.0±4.2</td>
<td>0.038</td>
</tr>
<tr>
<td>Mean sleep latency</td>
<td>23.4±14</td>
<td>16.1±12.7</td>
<td>NS</td>
</tr>
<tr>
<td>Smoking (%)</td>
<td>17.4</td>
<td>36.8</td>
<td>NS</td>
</tr>
<tr>
<td>Habitual coffee drinking (%)</td>
<td>69.6</td>
<td>63.2</td>
<td>NS</td>
</tr>
<tr>
<td>Habitual alcohol drinking (%)</td>
<td>47.4</td>
<td>42.1</td>
<td>NS</td>
</tr>
</tbody>
</table>

Self-reported behaviour

Driving >20000 km/year (%) | 60.9 | 50.0 | NS | 44.4 | 50.0 | NS | 71.4 | 50.0 | NS |
Driving at night (%) | 47.8 | 75.0 | NS | 33.3 | 66.7 | NS | 57.1 | 64.3 | NS |
Sleeping while driving at least monthly (%) | 43.5 | 35.0 | NS | 66.7 | 50.0 | NS | 28.6 | 28.6 | NS |
Stopping driving while sleepy (%) | 39.1 | 30.0 | NS | 100.0 | 100.0 | NS | 0.0 | 0 | NS |
Sleep attacks while driving at least monthly (%) | 26.1 | 35.0 | NS | 33.3 | 50.0 | NS | 21.4 | 28.6 | NS |
Near-miss accidents in the last 5 years (%) | 17.4 | 35.0 | NS | 0.0 | 16.7 | NS | 28.6 | 42.9 | NS |
Sleepiness-related accident (%) | 0.0 | 70.0 | <0.0001 | 0.0 | 66.7 | NS | 0.0 | 71.4 | 0.0001 |

Mean driving simulator parameters

Crashes (n) | 0.5±1.0 | 2.7±5.9 | NS | 0.9±1.5 | 6.3±8.8 | NS | 0.2±0.3 | 1.2±2.4 | 0.036 |
Time to first crash (min) | 27.1±5.1 | 22.3±8.6 | 0.050 | 14.2±7.1 | 22.3±10.8 | NS | 28.9±1.8 | 22.2±0.0 | 0.007 |
Lane position variability (m) | 0.0±0.3 | 0.0±0.3 | NS | 0.5±0.1 | 0.7±0.5 | NS | 0.4±0.1 | 0.6±0.2 | 0.017 |

Continuous data are presented as mean±SD.

AHI, apnoea–hypopnoea index; BMI, body mass index; ESS, Epworth sleepiness scale score; MWT, maintenance of wakefulness test; NS, not significant.
individual behaviours of sleepy drivers. Our data, albeit from a limited number of patients with OSAS, support the reliability of a driving simulator approach for the identification of patients with OSAS at risk: poor performers have high risk if they keep on driving when sleepy. Accordingly, poorer simulated driving performance was associated with crash history only in our subjects with ‘tisky’ behaviour. Nevertheless, the use of driving simulators is still recommended as a research tool given the absence of a standardisation that is the prerequisite for use in clinical practice.

Finally, crash risk is a multifactorial entity. Even if it is highly influenced by sleepiness, individual behaviours have a prominent effect in letting sleepiness determine a car accident. We emphasise that educational programmes, potentially involving driving simulators in different settings, remain the key instrument for risk management of sleepiness-related car accidents.

**References**


