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SHORT PAPER

Second-hand smoke exposure generated by new electronic devices (IQOS® and e-cigs) and traditional cigarettes: submicron particle behaviour in human respiratory system

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Parole chiave: Sigarette elettroniche, IQOS®, fumo passivo, particelle submicroniche.

Abstract

Passive exposure profiles to submicronic particles (SMPs, 5.6-560 nm) of traditional cigarettes and new electronic commercial devices (e-cig and IQOS®, a new heat-not-burn smoking device) were compared. During smoking, SMPs released by traditional cigarettes resulted four-times higher than those released by electronic and heat-not-burn devices and remained high for at least one hour, while SMPs values returned immediately similar to background for electronic and heat-not-burn devices. In all experiments, approximately half of SMPs resulted so small to reach the alveolar region.

Introduction

Despite the scientific debate on electronic cigarette (e-cig), medical practitioners may struggle to provide an "evidence-based" response to patient inquiries about the potential health effects of passive exposure to non-combustible nicotine and tobacco devices. This is due to the limited evidence currently available on this topic (1-4). Also, differences in the toxic compounds released into the atmosphere by different types of electronic devices may occur, due to their specific operating characteristics (cartridge sizes, heating elements and batteries) and the variety of available refill solutions (5-7). These substances also differ from those generated by traditional cigarettes (8). To make matters worse, new heat-not-burn tobacco products are entering the market, such as IQOS®, an electronic device that heats a cigarette-like stick without combustion. We are not aware of any scientific literature on the risks posed by passive exposure to the IQOS®. A comparative evaluation between IQOS®, e-cigs and traditional cigarettes is challenging due to potential differences in the substances produced by these different

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products. This problem can be overcome by the measurement of submicronic particles (SMPs), which are always released during use of all these different products. The aim of the present research was to compare the profiles of exposure to passive smoking determined by the indoor use of combustible cigarettes, heat-not-burn devices and e-cigs. Thus, we measured submicronic particles generated by volunteers who smoked each of the following products indoors: one traditional cigarette (Pall Mall® San Francisco), one hand-rolled cigarette (Golden Virginia® tobacco hand-rolled with a Rizla® Blue Regular Rolling Paper), 12 e-cig puffs (Smooke® E-SMART (L) e-cig filled with Smooke® Light e-liquid containing nicotine at 9 mg/mL), and one IQOS® stick. Smoker volunteers were two researchers of Sapienza University of Rome (one 53 years old male and one 37 years old female, already current smokers).

Methods

SMPs were measured in 2015 using a Fast Mobility Particle Sizer spectrometer (FMPS 3091, TSI Inc.) in a room of 52.7 m^3 with a door and a window (room air changes: 0.67 air changes/h). The FMPS 3091 measures particle size distribution in the range 5.6-560 nm using the electrical mobility technique, with a 1-s time resolution. To simulate passive exposure of the subjects, we placed the air sampler 2 meters away from the smoker and at 1.5 meters above the floor. The door and the window were opened before each experiment to reach a steady SMPs concentration; then, the door and the window were kept closed until the end of each experiment. For each experiment, lasting one hour from the cigarette or device ignition, we also modelled the SMPs deposition dose in the human respiratory tree with the Multiple-Path Particle Dosimetry model (MPPD v2.1, ARA 2009) (9). Each experiment was run in triplicate; arithmetic mean values were calculated for each 1-s time measurement and used for data comparison.

The study was non-sponsored and was approved by the local Ethical Committee (Policlinico Umberto I/Sapienza University of Rome; protocol code 3520).

Results

The key results emerged from the experiments (Figure 1) are:

1. during smoking, SMPs released by traditional and hand-rolled cigarettes and deposited in the respiratory tract of a passively exposed subject are four-times higher than those released by electronic and heat-not-burn devices;

2. after smoking, SMPs generated by traditional and hand-rolled cigarettes remain high until the end of the experiment (about six-times higher than background) while, for electronic and heat-not-burn devices, SMPs values return immediately very similar to background; it is presumable that SMPs generated by heat-not-burn smoke coalesce with each other rapidly and in large numbers, increasing their average diameter and settling immediately. On the contrary, SMPs generated by burn maintain their dimension and, thus, they persist in air for a much longer time;

3. in all experiments, approximately half of the deposited SMPs resulted so small as to be able to reach the alveolar region of passively exposed subjects;

4. one hour spent indoor in which a single traditional cigarette, hand-rolled cigarette, e-cig, or IQOS® is smoked determines an exposure to SMPs equivalent to that which would occur spending respectively 49, 39, 12, and 10 minutes in a heavy traffic area (10).

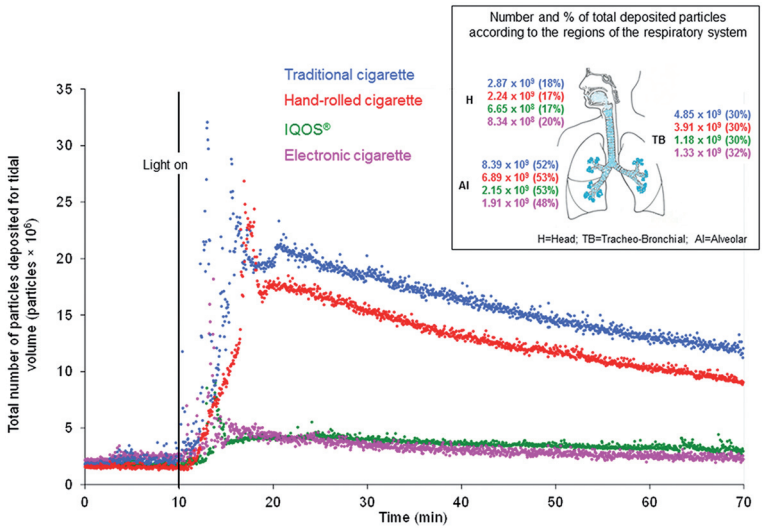

Fig. 1 - Calculated submicronic particles with a nominal diameter in the range 5.6-560 nm (mean values of three replicates): instant doses (graph) and size-distribution (%) in different respiratory regions (box) for a normal nose breathing-adult male in rest condition

Discussion and Conclusions

In conclusion, even if our experiments were carried out on a limited number of products, and the tests were performed in a single enclosed environment, preliminary results showed that exposure to SMPs generated by electronic devices occurs only during the smoking period, and it becomes negligible when the device is turned off. However, exposure to SMPs when electronic devices are used indoors does occur, and it is likely that a high proportion of the particles inhaled reach the alveolar region.

Riassunto

Esposizione a fumo di seconda mano generato dai nuovi dispositivi elettronici (IQOS® ed e-cigs) e da sigarette tradizionali: comportamento delle particelle submicroniche nel sistema respiratorio umano

Sono stati confrontati i profili di esposizione passiva a particelle submicroscopiche (*submicronic particles* - SMPs, 5,6-560 nm) generate da sigarette tradizionali e da dispositivi elettronici commerciali (e-cig e IQOS®, un nuovo dispositivo per fumare che riscalda uno stick ma non brucia tabacco).

Durante il fumo, le concentrazioni in aria di SMPs emesse dalle sigarette tradizionali sono risultate superiori di quattro volte sia rispetto a quelle determinate da e-cig che a quelle determinate da IQOS®. Tali concentrazioni sono rimaste elevate per almeno un'ora dopo il fumo nel caso di sigarette tradizionali, mentre sono tornate immediatamente simili ai livelli di fondo nel caso di e-cig e IQOS®. In tutti gli esperimenti, comunque, circa la metà delle SMPs è risultata di dimensioni sufficientemente ridotte da essere in grado di raggiungere la regione alveolare polmonare.

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