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Particle related air exposure during physical exercise: levels, dose and deposition in respiratory system

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The life of 21st century has become more sedentary, which promotes higher prevalence of non-communicable diseases; about one third of worldwide adult population is insufficiently active which translates to 6% of global deaths. Furthermore, physical inactivity combined with unsuitable diet may lead to increased obesity. In order to improve the overall health and well-being, various national and international organizations recommend to practice physical exercise on regular basis. In cities, outdoor exercising is the most common and accessible form of exercising. However, the respective benefits can be reduced or even outweighed by the adverse effects of air pollution. Thus, this work aimed to evaluate the influence of air pollution on human inhalation dose and deposition in respiratory tract while conducting different types of physical exercise.

Information on levels of PM2.5 and PM10 was obtained from the national system of monitoring stations for cities Oporto and Lisbon along 2015-2018. A total of 5358 subjects was used to assess the anthropometric data of Portuguese population and its exercise habits. Inhalation dose were estimated for specific age categories of children and adult, considering different exposure and physical exercise scenarios and using age-specific parameters. The deposition of particles in the respiratory system was estimated by Multiple-Path Particle Dosimetry Model (version3.04, ARA).

Traffic-originated PM2.5 and PM10 were the relevant pollutants for the exposure assessment while exercising in the selected areas; PM10 daily limit of 50 μg/m³ was exceeded up to 40% of stations. The anthropometric data were rather similar between the populations of both studied areas. Furthermore, the results indicated that vast part of the adult population is overweight (body mass index of 25 to 29.9 kg/m²), with approximately 25% of subjects being obese in an age-range of 41-60 years old. The dose exposure to PM pollutants were in general higher in autumn when compared to spring. The highest inhalation dose was observed for the youngest children (<6 years) mostly due to longer time exposure (60 min per day vs. 150 or 300 min per week for adults) and due to their higher minute ventilation rate relative to body mass. In adults, the prolonged exercise duration influenced greatly the particle dose, being up to 1.1 times higher for moderate activities than for intense ones. Concerning the particle deposition within human respiratory system, the total of deposited fraction was higher for PM10, being deposited in the head (65-95% for all age group total deposition fraction) and tracheobronchial (1-23%) regions. Fine PM deposition in respiratory system was as follows: 16-76% in the head, and 13-33% in pulmonary region, being the lowest in tracheobronchial region (3%). Across all the physical exercise scenarios and across all adult age categories, higher deposition was observed for lower pulmonary lobes – for PM10 it was 33% in left lower and 32% in right lower lobe, whereas the lowest abundance was observed the right middle lobe (8%). For PM2.5 the respective percentages were: 19% in left lower and 26% in right lower lobe; in right middle lobe the abundance was 7%.