Bioenergetic status of human intestinal Caco-2 cells after exposure to simulated environmental nanoplastics

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The ubiquitous human exposure to nanoplastics (NP) in our daily life increasingly raises concerns regarding our health. Currently, it is difficult to evaluate effects of NP in real-life exposure as substantial studies exposed human cells to pure nano-polymer particles with rather high concentrations, which cannot represent complicated NP samples suffering weathering in our living environment. In this study, the bioenergetic effects of four simulated environmental NP samples on human intestinal Caco-2 cells were investigated. To this aim, big micro-PET particles were mechanically milled into a lower size range sample (M-PET) with multiple shapes. Then the M-PET particles and a PS mixture (100 nm and 700 nm, mixed) were irradiated by ultraviolet (UV) light for 1273 h, corresponding to 15 months of central European solar irradiance exposure. After weathering procedures, both virgin and UV-weathered M-PET samples were filtered by 0.8-µm filter to obtain nano-PET particles with size less than 800 nm. Subsequently, Caco-2 cells were exposed to nano-PET and nano-PS samples with and without UV weathering at realistic exposure levels (10^1-10^7 particles/mL) for 48 h. The mitochondrial respiration and glycolytic parameters of exposed cells were measured by Seahorse XF96 Analyzer. Based on these results, the harmful impacts of nano-PET on cellular bioenergy were stronger than those of nano-PS. Basal respiration, spare respiratory capacity, proton leak and basal glycolysis were stimulated by stress from exposure to both virgin and UV-weathered nano-PET samples. Comparing virgin and UV-weathered nano-PET, the negative effects on mitochondrial respiration were alleviated while anaerobic glycolysis was enhanced for UV-weathered PET. Similarly, mitochondrial functions were more sensitive to virgin nano-PS while basal glycolysis was more vulnerable to UV-weathered PS sample. This research is the first to study bioenergetic responses of simulated environment NP samples on human health. It highlights that effects between pristine and weathered NP are different at a bioenergetic level, which has important implications for the risk assessment of NP on human health.

Keywords
Environmental Nanoplastic; UV Weathering; Mitochondrial Respiration; Basal Glycolysis; Human Exposure