PhD Research Project

Title:

Role of Micro- and Nanoplastics in Metabolic Inflammation

Introduction

Obesity is a multifactorial condition resulting from chronic energy imbalance. Recent studies suggest that ultra-processed foods — often containing micro- and nanoplastics (MPs and NPs) — represent an emerging environmental factor in the pathogenesis of obesity (Chooi et al., 2019). Plastics are ubiquitous and originate both from food and everyday consumer products (Kim et al., 2025). Once ingested, MPs and NPs may accumulate in tissues, leading to cytotoxic, inflammatory, and mitochondrial effects (Fan et al., 2022; Wang et al, 2024).

Despite preliminary evidence, it is still unclear whether and how MPs and NPs may directly contribute to metabolic dysfunctions and trigger pro-inflammatory phenotypes such as the Senescence-Associated Secretory Phenotype (SASP) in white adipocytes. This project aims to fill this gap.

Project Objectives

1. Analyze the predisposition of obese individuals to accumulate MPs/NPs in white adipose tissue.

2. Characterize the internalization mechanisms and impact on lipid and mitochondrial metabolism in adipocytes.

3. Assess the role of MPs/NPs in the induction of the SASP phenotype in white adipocytes.

Methodology

In vitro experiments
- Internalization: Fluorescent/confocal microscopy and flow cytometry using fluorescent beads. Use of endocytosis inhibitors to identify uptake pathways.
- Metabolism and toxicity: Cell viability assays, RT-PCR, Western blotting, RNA-Seq, and mitochondrial function evaluation on 3T3-L1 and SGBS lines.
- Senescence: ROS quantification, senescence markers, SASP phenotype, Oil Red O staining, p16/p21 knockdown, and antioxidant treatment (N-acetylcysteine).

In vivo experiments
- High-fat diet (HFD) mouse model exposed to NPs via drinking water. Analysis of weight,

glycemia, visceral and subcutaneous adipose tissue (inflammation, macrophage infiltration, SASP).

International Experience

During the second year (last six months), a research stay is planned at the laboratory of Prof. Andreas Prokesch at the Gottfried Schatz Research Center (Medical University of Graz), to deepen:
- advanced techniques for mitochondrial imaging and bioenergetics;
- study of lipid metabolism under oxidative stress and cellular senescence;
- integration with translational and human-based models.

Expected Results and Impact

This project aims to clarify the environmental contribution of plastics to metabolic dysfunction, providing a basis for new preventive and therapeutic strategies. The objectives are to:
- identify new risk markers related to MPs/NPs;
- explore poorly understood molecular mechanisms of obesity;
- open new perspectives for targeted interventions limiting the impact of environmental contaminants on metabolic health.

Gantt Chart

Activity	Year 1	Year 2	Year 3
Literature review	●●●◐		
In vitro experiments: internalization	●●●	●	
In vitro experiments: metabolism/SASP		●●●	●
In vivo experiments		●◐	●●◐
Data analysis and publications		●◐	●●◐
International stay (Graz, 6 months)		●●●	
Thesis writing			●●●

With ●= 2 months and ◐=1 month

Bibliography

1. Chooi, Y.C., Ding, C., and Magkos, F. (2019). The epidemiology of obesity. Metabolism 92, 6–10.
2. Kim, J.E., Sonar, N.S., Thakuri, L.S., Park, J.W., Kim, K.-T., and Rhyu, D.Y. (2025). Mixtures of polystyrene micro and nanoplastics affects fat and glucose metabolism in 3T3-L1 adipocytes and zebrafish larvae. NanoImpact 37, 100549.
3. Fan, X., Wei, X., Hu, H., Zhang, B., Yang, D., Du, H., Zhu, R., Sun, X., Oh, Y., and Gu, N. (2022). Effects of oral administration of polystyrene nanoplastics on plasma glucose metabolism in mice. Chemosphere 288, 132607.
4. Wang, S., Ma, L., Chen, L., Sokolova, I.M., Huang, W., Li, D., Hu, M., Khan, F.U., Shang, Y., and Wang, Y. (2024). The combined effects of phenanthrene and micro-/nanoplastics mixtures on the cellular stress responses of the thick-shell mussel Mytilus coruscus. Environmental Pollution 341, 122999.