THE PRESENCE OF MICROPLASTICS IN MALE GONADS AND THEIR IMPACT ON FERTILITY

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Abstract

Introduction: Plastic, a synthetic polymer composed of carbon chains, facilitates modern life. Microplastics, with diameters between 0.1 and 5 mm, can be intentionally manufactured or generated from plastic degradation. They are environmental pollutants, present in food and water, and have been found in mammalian testes, including humans. **Materials and Methods**: This is an integrative review that used DeCS descriptors to search the Elsevier, MedLine, PubMed, and Cochrane databases, selecting articles according to the PICO strategy. Articles published between 2019 and 2024 in English and Portuguese were included. Initially, 39 articles were found, of which 6 were selected for review. **Results**: The interference of bisphenol A (BPA), di-n-butyl phthalate (DBP), polystyrene (PS), and polyvinyl chloride (PVC) in extracellular metabolism was demonstrated through lesions to Leydig cells. Three studies reported that nanoplastics induce testicular inflammation in mice, impairing gametes and testosterone production. **Conclusion**: Microplastics in testes may interfere with spermatogenesis and testosterone production.

Keywords: Men; Testosterone; Plastics.

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INTRODUCTION

Since the Industrial Revolution, human contact with plastics has increased. Plastics are synthetic polymers formed by monomers of nonpolar carbon chains. Microplastics are solid particles derived from these polymers, either for primary purposes or resulting from environmental degradation of plastics. Global plastic production has surpassed 300 million tons per year (Barbara M. et al., 2022). Due to large-scale manufacturing, these materials are extensively discarded, resulting in massive environmental accumulation as non-biodegradable waste (SUN et al., 2023). Thus, microplastic pollution constitutes an environmental problem due to its cumulative effects in organisms (Barbara M. et al., 2022).

Microplastics act in the human body as endocrine disruptors, particularly affecting the reproductive cycle. Synthetic compounds influence structures responsible for fertility (Batista et al., 2023). Male gonads are affected by the accumulation of these synthetic polymers, which are present in support cells, Sertoli cells, and testosterone-producing Leydig cells (Marques-Pinto A. et al., 2013).

Testosterone is the main male sex hormone and also functions as an anabolic steroid important for secondary male characteristics. According to Leong et al. (2019), microplastics may reduce serum testosterone levels by impairing its synthesis. This study aims to evaluate the impact of environmental microplastics on male reproduction through an integrative review.

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METHODOLOGY

This integrative review used DeCS/MeSH descriptors: “Men”; “Testosterone”; “Plastics” across PubMed, Cochrane, MedLine, and Elsevier databases. Studies were selected according to PICO eligibility criteria: male subjects exposed to environmental microplastics potentially exhibiting reduced serum testosterone levels and sperm production. Original research articles published in English or Portuguese between 2019 and 2024 were included, while prognostic, etiological, and incomplete studies were excluded.

RESULTS AND DISCUSSION

The six selected original articles provided information on the main histopathological findings and the effects of microplastic accumulation in mammalian gonads.

Table 1. Main information from the reviewed articles

Autor e ano	**Título**	**Tipo de estudo**	**Resultados**

(LI *et al*., 2024)	*"Combined effects of polystyrene nanoplastics and lipopolysaccharide on testosterone biosynthesis and inflammation in mouse testis"*	Estudo experimental pré-clínico in vivo	Refere-se à uma coexposição a bactérias ambientais e nanoplásticos e efeito sinérgico para a redução da fertilidade em camundongos. Um recorte do lúmen no túbulo seminífero revelou presença de poliestireno o qual aumenta a acidez no testículo gerando estresse oxidativo das Células de Sertoli
(CZARNYWOJTEK *et al*., 2021)	*"The effect of endocrine disruptors on the reproductive system – current knowledge"*	Revisão narrativa	Foi mostrado que Bifenilos policlorados (PCBs) pelo seu caráter lipofílico são permanentes nos testículos de caráter cumulativo. O polietileno leva à disgenesia de espermatozoides.
(SUN *et al*., 2023)	*"Exposure to nanoplastics induces mitochondrial impairment and cytomembrane destruction in Leydig cells"*	Estudo experimental in vitro	Elucidou que o nanopoliestireno teve ação deletéria nas CL^2 a longo prazo. Mostrou redução na densidade e alternância na morfologia em células expostas ao nanoplástico e evidenciou que os microplásticos nas células TM3 tem poder lesivo sobre as CL.
(BARBAGALLO *et al*., 2020)	*"Effects of Bisphenols on Testicular Steroidogenesis"*	Estudo experimental in vivo e in vitro	Policarbonatos interferiram na síntese de enzimas esteroidogênicas. A exposição direta sobre os testículos levou à apoptose das CL por via FasL com suprarregulação de oncogenes.
(KÄLLSTEN *et al*., 2022)	*"Adult Exposure to Di-N-Butyl Phthalate (DBP) Induces Persistent Effects on Testicular Cell*	Estudo experimental in vivo	O contato de humanos com Di-N-Butil Ftalato (DBP) pode ter induzido a diminuição da testosterona, mas não na androstenediona demonstrando a interferência dos microplásticos em

	Markers and Testosterone Biosynthesis in Mice"		enzimas conversoras, como 17,8-HSD, na gênese de testosterona.
(KÄLLSTEN *et al*., 2022)	*"Di-n-Butyl Phthalate and Its Monoester Metabolite Impairs Steroid Hormone Biosynthesis in Human Cells: Mechanistic In Vitro Studies"*	Estudo experimental in vivo	Nesse estudo a exposição aos derivados de bisfenol em um curto prazo (48 horas) foi suficiente para detectar alterações na produção de testosterona. Houve, redução de proteínas importantes e aumento do estresse oxidativo das Células de Leyding.

Fonte: Próprio autor, 2024.

Among the most frequently found microplastics are Di-n-butyl phthalate (DBP), polycarbonates (PCs), and polychlorinated biphenyls (PCBs). The PCBs showed significant results regarding toxicity on Leydig cells, which produced reduced amounts of testosterone. These compounds were observed to affect the maturation of spermatogonia, thereby impairing sperm formation (Czarnywojtek et al., 2021).

Regarding the mechanism of microplastic toxicity in Leydig cells, Sun et al. (2023) report that apoptosis is one of the mechanisms through which polycarbonates destroy testicular cells, particularly Leydig cells. Activation of the extrinsic Fas apoptotic pathway with its ligand was observed. A recent study by Barbagalo et al. (2023) demonstrates that microplastics, by irritating the cell membrane surface, exerted damaging effects on Leydig cells, reducing their population. The presence of microplastics also leads to decreased testicular pH, generating oxidative stress in Sertoli cells and triggering inflammatory signals in the seminiferous tubules, ultimately reducing spermatogenesis.

The biosynthesis of testosterone depends on the activation of phosphokinases, which phosphorylate and synthesize proteins necessary for steroid production. It was observed that synthetic compounds affect the conversion of androstenedione into testosterone. This action consists of the chemical interaction of DBPs with proteins

responsible for steroidogenesis. These synthetic compounds interact with the enzyme “17β-HSD,” reducing its availability for testosterone precursors and thereby impairing the biosynthesis process (Källsten et al., 2022).

Finally, it is important to note that these synthetic compounds accumulate in human tissues. Accumulation occurs at an accelerated rate due to environmental exposure (Barbara M. et al., 2022). Evidence shows that within 48 hours, the amount of bisphenol was sufficient to reduce serum testosterone levels in a mammal exposed to the compound under controlled conditions. This was confirmed by fluorescent histological markers indicating increased oxidative stress in Leydig cells (Källsten et al., 2022).

CONCLUSION

In light of the above, studies suggest the presence of environmental microplastics accumulating in mammalian gonads. These synthetic compounds are deleterious to testosterone steroidogenesis, reducing levels either through Leydig cell injury and apoptosis or by intercepting hormone precursors. Another finding that poses a risk to human reproduction is the dysgenesis of reproductive cells caused by synthetic plastic compounds. Finally, it is imperative to highlight the need for further studies on this topic, given its importance for human reproductive health.

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