A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP10551.

A Measure of Strength: Developmental PFAS Exposures and Bone Mineral Content in Adolescence

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https://doi.org/10.1289/EHP10551

The amount of bone mass that accumulates during early childhood and adolescence is a significant factor governing skeletal strength and the risk of osteoporosis in older adults.[1,2] Growing evidence suggests developing bone may be damaged by exposures to per- and polyfluoroalkyl substances (PFAS).[3] A new study in *Environmental Health Perspectives*[4] associates higher concentrations of PFAS in maternal blood during pregnancy with lower measures of bone strength in adolescent children. The study was led by Jessie Buckley, an associate professor of environmental health and engineering at the Johns Hopkins Bloomberg School of Public Health in Baltimore, Maryland.

Commonly described as "forever chemicals" because they are exceedingly resistant to degradation, PFAS have been used as stain, oil, and water repellents and as surfactants in fire-fighting foam.[5] Certain PFAS are being phased out of production, but other novel formulations are being introduced to take their place.[6]

Buckley and colleagues analyzed data collected by the Health Outcomes and Measures of the Environment (HOME) study, which enrolled pregnant women from Cincinnati, Ohio, and the surrounding areas between 2003 and 2006. This ongoing study aims to assess how fetal and early-life chemical exposures affect children's growth and development.[7] The women provided blood samples at 16 and 26 weeks of pregnancy and within a day of their child's delivery. For the current study, the investigators measured PFAS in one sample per participant, with all three sampling points represented in the study.

Buckley's team analyzed data for 206 children from the HOME cohort who had also undergone dual-energy X-ray absorptiometry bone scans at 12 years of age. These scans measure inorganic bone mineral, which gives the skeleton its strength.[8] Using those data, the researchers calculated two bone measurements: bone mineral content (BMC) and bone mineral density (BMD). The team then looked at how BMC and BMD measures varied with maternal blood concentrations of four PFAS: perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS), and perfluorooctane sulfonic acid.

Higher concentrations of PFOA and PFNA individually and of all four PFAS assessed as a mixture were associated with lower *z*-scores for BMC and BMD in the forearm and hip. The lower *z*-scores suggest that children with higher PFAS exposures had lower average bone mass compared with individuals of the same age, sex, and ancestry. "The mixture's relationship with bone outcomes was stronger than the relationship [of any single]

Resistance to bone diseases such as osteoporosis depends on maximizing bone mass during critical growth periods, which include adolescence. A new study reports associations between higher prenatal PFAS exposures and lower measures of bone strength in 12-year-olds, with potential implications for adult bone health. Image: © Sergey Novikov/Shutterstock.

PFAS," Buckley says. "This is important, since in the real world people tend to be exposed to mixtures of different PFAS all at once."

Abby Fleisch, a pediatric endocrinologist at Maine Medical Center in Portland, who was not involved in the research, says the study has several strengths. "It identifies gestation as a possible vulnerable window for PFAS exposures to impact bone health later in life," she says. Furthermore, prospective data gathered so far have been limited to females, whereas Buckley and colleagues studied both sexes. Indeed, higher maternal PFOA concentrations were generally associated with lower *z*-scores in males compared with females. However, a key limitation, Buckley says, is that small sample sizes resulting from losses during follow-up made it difficult to assess sex-related differences.

Still, the study addresses "important questions regarding prenatal exposure to both individual and mixtures of PFAS," says Meghan Lynch, an environmental epidemiologist and PFAS expert at Abt Associates, an environmental consulting company headquartered in Rockville, Maryland. "Decreases in BMD in childhood are linked to an increase in fractures and the development of osteoporosis," she says. "More research is needed to understand if this [association with PFAS] persists and if it is exacerbated by ongoing exposure to PFAS through adolescence and beyond."

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