On an isotropic porous solid cylinder: the sensitivity analysis of the pressure, stresses, and displacement

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Carrying out a sensitivity analysis as an uncertainty and variance-based technique clarifies the effects of material input parameters on the pressure, stresses, and displacement of an isotropic porous solid cylinder, which models hard mechanical systems like bone. This presentation considers the modeling of the system through the governing equations of Biot's poroelasticity in cylindrical polar coordinates, where solutions are obtained by applying radial boundary conditions. The sensitivity analysis is performed on the solutions for pressure, stress components, and displacement, utilizing ranges of parameters that reflect the characteristics of bone. The research indicates that the time t^* has the most considerable impact on pressure, stress components, and displacements. Furthermore, it is found that the Poisson ratio ν has a more significant influence on the pressure response than the shear modulus μ, while the shear modulus mu is more critical than other parameters in relation to radial and circumferential stresses. There are significant interactions between Biot's coefficient α, the Poisson ratio ν, the non-dimensional radius R^* of the bone, and Biot's modulus M when examining interstitial pressure, which is vital for bone remodeling and fracture healing. This study lays the groundwork for a deeper understanding of the interactions among all parameters necessary to accurately capture the behavior of hard mechanical systems, such as bone and its potential for remodeling.

References

[1] Asghari, H., et al. *The sobol sensitivity analysis of the pressure, stresses, and displacement arising from poroelastic modelling of hard mechanical systems.* Sci Rep 15, 44378 (2025). https://doi.org/10.1038/s41598-025-28109-z

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