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Direct numerical simulation of human phonation[1] SHAKTI SAURABH, DANIEL BODONY, University of Illinois at Urbana-Champaign —
A direct numerical simulation study of the generation and propagation of the human voice in a full-body domain is conducted. A fully compressible fluid flow model, anatomically representative vocal tract geometry, finite deformation model for vocal fold (VF) motion and a fully coupled fluid-structure interaction model are employed. The dynamics of the multi-layered VF tissue with varying stiffness are solved using a quadratic finite element code. The fluid-solid domains are coupled through a boundary-fitted interface and utilize a Poisson equation-based mesh deformation method. A new inflow boundary condition, based upon a quasi-1D formulation with constant sub-glottal volume velocity, linked to the VF movement, has been adopted. Simulations for both child and adult phonation were performed. Acoustic characteristics obtained from these simulation are consistent with expected values. A sensitivity analysis based on VF stiffness variation is undertaken and sound pressure level/fundamental frequency trends are established. An evaluation of the data against the commonly-used quasi-1D equations suggest that the latter are not sufficient to model phonation. Phonation threshold pressures are measured for several VF stiffness variations and comparisons to clinical data are carried out.

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