Mechanosensitivity of bone cells to oscillating fluidflow induced shear stress may be modulated by chemotransport

T.L. Haut Donahuea,b,*, T.R. Hauta, C.E. Yellowleya, H.J. Donahuea, C.R. Jacobsa,c

aMusculoskeletal Research Laboratory, Department of Orthopaedics and Rehabilitation, Pennsylvania State University, College of Medicine,
Hershey, PA 17033, USA
bDepartment of Mechanical Engineering—Engineering Mechanics, Michigan Technological University, 1400 Townsend Dr. Houghton, MI 49931, USA
c Department of Mechanical Engineering, Palo Alto Veterans Affairs Medical Center, Stanford University, USA
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Abstract

Fluid flow has been shown to be a potent physical stimulus in the regulation of bone cell metabolism. In addition to membrane shear stress, loading-induced fluid flow will enhance chemotransport due to convection or mass transport thereby affecting the biochemical environment surrounding the cell. This study investigated the role of oscillating fluid flow induced shear stress and chemotransport in cellular mechanotransduction mechanisms in bone. Intracellular calcium mobilization and prostaglandin E2 (PGE2) production were studied with varying levels of shear stress and chemotransport. In this study MC3T3-E1 cells responded to oscillating fluidflow with both an increase in intracellular calcium concentration ([Ca2+]i) andan increase in PGE2 production. These fluid flow induced responses were modulated by chemotransport. The percentage of cells responding with an [Ca2+]I oscillation increased with increasing flow rate, as did the production of PGE2. In addition, depriving the cells of nutrients during fluidflow resultedin an inhibition of both [Ca2+]i mobilization andPGE 2 production. These data suggest that depriving the cells of a yet to be determined biochemical factor in media affects the responsiveness of bone cells even at a constant peak shear stress. Chemotransport alone will not elicit a response, but it appears that sufficient nutrient supply or waste removal is needed for the response to oscillating fluidflow inducedshear stress.