Effects of soluble silicon compound and deep-sea water on biochemical and mechanical properties of bone and the related gene expression in mice.

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Maehira F1, Iinuma Y, Eguchi Y, Miyagi I, Teruya S.

Author information:

1Laboratory of Biometabolic Chemistry, School of Health Sciences, Faculty of Medicine, University of the Ryukyus, 207 Uehara, Nishihara, Okinawa, Japan.

Abstract

Silicon has been known as an essential element for bone formation. The silicon contents of sea water increase with increasing of depth: 1.8 ppm Si in deep-sea water (DW) at 612 m in depth versus 0.06 ppm in surface sea water (SW). The effects of soluble silicon (Si) and DW from which NaCl was eliminated were studied in comparison with tap water (TW) and SW in cell cultures and in animal experiments using the control strain of senescence accelerated mouse, SAMR1. Si at 10 ppm as sodium metasilicate or 10% DW in the alpha-MEM medium stimulated cellular viability, marker enzymes of osteoblast and osteoclast cell lines, and the (45)CaCl(2) uptake in those cells in comparison with the medium control. After weanling SAMR1 were maintained for 6 months on a diet containing 200 ppm Si and 39% of DW and SW, DW and Si improved bone biochemical indices such as femoral weight, mineral and collagen content, and marker enzymes of bone formation and resorption as well as mechanical properties as compared to TW. In the femoral bone marrow of SAMR1, the mRNA expression of bone morphogenetic protein-2 (BMP-2), interleukin-11 (IL-11), and runt-related transcription factor 2 (Runx 2), which stimulate osteoblast development as well as type I procollagen (COL1A1) mRNA, were significantly increased in both DW and Si groups. The expressions of both osteoprotegerin (OPG) and receptor activator of NF-kappaB ligand (RANKL) were also elevated, resulting in distinct increases of the OPG/RANKL ratio in both DW and Si groups. The results indicated that a soluble silicate and deep-sea water as its natural material stimulated cell growth in both osteoblasts and osteoclasts in cell culture and promoted bone metabolic turnover in favor of bone formation through stimulation of the related mRNA expression in animal experiments.