



Harnessing Climate Intelligence for Bone Health: A New Era in Osteoporosis Prevention

Kemik Sağlığı için İklim Zekasından Yararlanmak: Osteoporozun Önlenmesinde Yeni Bir Dönem

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Dear Editor,

Osteoporosis affects millions of people around the world and affects the increase as the global population grows and sedentary habits become more widespread (1). Although genetic, hormonal changes and lifestyle factors such as diet and exercise have been considered the main causes for a long time, it is becoming clear that environmental factors also play an important role in bone health. Bone metabolism and osteoporosis' can influence the risk in many ways, which we only started to understand.

Recently, Nvidia introduced an artificial intelligence-supported climate modeling system called "Climate in a Bottle", which is designed to predict environmental changes with extraordinary accuracy. This system integrates real-time climate data and uses machine learning algorithms to simulate variables such as ultraviolet radiation, pollution levels, and temperature with high resolution. In this letter we would like to emphasize how such climate models can identify environmental conditions that may be involved in osteoporosis, opening new doors for preventive health strategy.

The production of vitamin D in the human body, which is essential for maintaining healthy bones and regulating calcium levels, mainly depends on exposure to sunlight, specifically ultraviolet B (UVB) radiation. However, environmental factors such as seasonal variations, geographic location, increasing air

pollution, and urban living often limit how much UVB people receive (2). In regions in which cloudy weather or air pollution blocks daylight for a long-term, vitamin D deficiency frequently turns into general, that's the cause of osteoporosis danger. With the help of advanced weather versions consisting of "Climate in a Bottle", it is possible to assume changes in sunlight and air pleasant. Such projections could support public health planning by indicating when and where vitamin D supplementation or safe sun exposure is needed most. This can provide fitness officials a strategy to develop a good deal higher for vitamin D fashion and show people when and how to safely receive solar radiation (3).

Weather conditions also play an important role in how active people are, especially older adults who are more likely to develop osteoporosis. When the weather is too cold or too hot, people tend to stay indoors and move less, which means they miss out on activities that help keep their bones strong. Research from a rural community in Thailand showed that people who stayed physically active and consumed enough calcium had better bone density and a lower risk of osteoporosis (1). If we can use weather forecasts to plan physical activity, we may be able to reduce the research risk group of osteoporosis.

Furthermore, emerging research has linked air pollution, particularly fine particulate matter (PM2.5), to reduced bone mineral density and increased fracture risk through systemic

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inflammation and oxidative stress (4). Predictive climate and pollution models can help identify high-risk regions and populations, enabling tailored prevention strategies.

Beyond environmental exposures, recent machine learning research has highlighted the importance of both individual-level (psychological, behavioral) and nation-level (economic, cultural) factors in shaping climate-relevant beliefs and behaviors (5). Integrating these behavioral insights with climate-based bone health data could help develop personalized osteoporosis prevention strategies, such as predicting individuals' sun exposure patterns or activity levels. This approach could be extended to osteoporosis research by integrating personal health data with environmental forecasts to create individualized bone health risk profiles.

In conclusion, osteoporosis prevention must evolve beyond static risk factor assessments to dynamic, predictive models that incorporate environmental changes. Tools like "Climate in a Bottle" provide new opportunities to anticipate and mitigate environmental risk factors for osteoporosis on both an individual and population scale. Collaborative efforts between climate scientists, bone health specialists, and public health policymakers are needed to translate these climate models into actionable health interventions.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.Ö., B.H., Concept: B.Ö., Design: R.Ç., Data Collection or Processing: F.B., B.H., Analysis or Interpretation: R.Ç., Literature Search: B.Ö., Writing: R.Ç., B.H.

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