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Short communication

Unlocking precision nutrition: the expanding role of nutrigenetics

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Introduction

Marked inter-individual differences in response to identical dietary interventions challenge the assumption that population-based nutrition advice is universally effective. This biological variability has driven the emergence of Precision Nutrition (PN), an approach that tailors dietary recommendations according to individual biological characteristics.

Among the disciplines underpinning PN, Nutrigenetics (NGx) has emerged as one of its principal drivers by providing a mechanistic understanding of how inherited genetic variation influences nutrient metabolism, physiological responses to diet and disease susceptibility. Accumulating evidence demonstrates that common genetic variants contribute to differential dietary responses, providing the basis for individualized nutritional recommendations beyond population-level guidance (Ordovas et al., 2018).

Recent advances position NGx as the biologically stable framework upon which multi-omic approaches are increasingly integrated. Unlike dynamic biological layers, the genome provides a lifelong reference that strengthens the interpretation of complementary omic data within PN (Fu et al., 2026). This review highlights the evolution of NGx from elucidating gene–diet interactions to underpinning the clinical implementation of PN.

From gene–diet interactions to clinical translation

Evidence supporting NGx has evolved considerably over the past decade. Initially dominated by observational studies, NGx is now supported by large prospective cohorts, randomized controlled trials and systematic reviews, substantially strengthening both the reproducibility and clinical relevance of NGx research.

Although NGx evidence is emerging across numerous health conditions, the greatest translational maturity has been achieved in cardiometabolic disease, obesity and type 2 diabetes (T2D), where findings have been consistently replicated in prospective cohorts and intervention studies. Genetic variants involved in lipid metabolism, glucose homeostasis, energy balance and inflammatory pathways have consistently been associated with differential responses to dietary components, contributing to inter-individual variability in disease susceptibility and responses to dietary interventions (Kapellou et al., 2025). Likewise, recent systematic reviews and meta-analyses demonstrate that polygenic susceptibility modifies the relationship between dietary exposures and obesity-related outcomes, supporting the development of more individualized weight-management strategies (Masip et al., 2025).

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The translational potential of NGx is perhaps best illustrated in T2D, where evidence has progressed from biological plausibility to clinical application. Prospective cohort studies have shown that adherence to a Mediterranean dietary pattern can substantially attenuate disease risk among individuals with a high polygenic risk score (Merino et al., 2022), while randomized controlled trials have demonstrated that genotype-informed nutrition advice significantly improved glycaemic outcomes compared with standard care (Karvela et al., 2024). Taken together, these findings provide robust evidence that genetic information can enhance dietary interventions when integrated with established nutritional strategies.

Collectively, these advances demonstrate that NGx has progressed from biologically plausible gene–diet interactions to clinically actionable evidence. As prospective cohorts and randomized trials continue to expand across diverse health conditions, the role of NGx within PN is expected to become increasingly relevant to evidence-based nutritional practice. Crucially, NGx does not replace established dietary recommendations but refines them according to individual biological variability.

NGx: the foundation of next-generation PN

As PN evolves towards increasingly sophisticated multi-omic frameworks, NGx is not being replaced but repositioned within a broader systems biology approach. Rather than functioning in isolation, NGx provides the biological foundation for integrating complementary molecular and phenotypic data into personalized nutrition.

Unlike the metabolome, microbiome and transcriptome, which continuously respond to dietary intake, environmental exposures and physiological status, the genome remains stable throughout life. This temporal stability provides a biologically interpretable reference against which other omic datasets can be contextualized, strengthening both mechanistic understanding and the interpretation of inter-individual variability in dietary responses (Fu et al., 2026).

The future of PN is therefore unlikely to depend on single biological layers but on the integration of complementary information. Within this framework, NGx provides the stable reference against which dynamic molecular, clinical and lifestyle data can be interpreted, facilitating precise nutritional strategies. Far from being superseded by emerging technologies, NGx is becoming increasingly important as the framework that translates biological complexity into clinically applicable PN.

Conclusion

The future of PN will depend not on the accumulation of increasingly complex biological data alone, but on our ability to interpret this complexity in clinically meaningful ways. Within this landscape, NGx provides the stable biological framework that links inherited genetic variation with individual dietary responses, enabling more precise and evidence-based nutritional care. Importantly, NGx complements established dietary recommendations by refining them according to individual biological variability. The expanding role of NGx lies in providing the scientific foundation upon which the next generation of PN will be built.

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