Review on Prakriti-Based Personalized Medicine: Integrating Ayurveda and Genomics

Abstract

The personalized medicine is transforming the present-day clinical practice, by customizing the interventions based on individual biological differences. Tailor-made health systems based on personalized approach and Prakriti have been suggested in the ancient Indian system of medicine, Ayurveda where Prakriti is an individual's body constitution which comprises three doshas Vata, Pita and Kapha in relative proportions of these. Modern genomics and molecular biology, in recent years have supplied scientific bases to this age-old concept, and have entified associations between Prakriti types and genetic make-up, metabolic activity of the individual as well as immunological profile and disease predisposition. In this article, we critically examine the inclusion of Prakriti-based classification as crossways into genomic science and its implications in predictive, preventive, and personalized medicine. We also address recent findings on genome-wide associations, transcriptomics, epigenetics and pharmacogenomics validating Prakriti as a biologically representative endophenotype. The integration of Ayurveda and modern omics technologies seems a successful journey towards future precision medicine.

Keywords: Prakriti, personalized medicine, Ayurveda, genomics, pharmacogenomics, systems biology

Introduction

The development of molecular biology and in particular genomics, transcriptomics and metabolomics have transformed the practice of medicine from an art to a science, from an empirical approach –one size fits all – towards individualized medicine, where treatments are made based on human biological information. This individualized medicine is intended to improve therapeutic efficacy and minimize side effects in order to promote health outcomes by taking considerations of genetic variability, environmental determinants and lifestyle contributors (1,2).

Several discoveries from the Human Genome Project (HGP) that lasted until 2003 and advances in next-generation sequencing (NGS) technologies have highlighted genetic factors that account for disease predisposition, drug responsiveness, and metabolic variability (3). However, despite these advances, the genomic paradigm frequently fails to account for the complexity of human individuality, which is influenced by epigenetics, environmental exposures, diet, microbiome diversity and psychosocial issues (4).

The classical literature of Ayurveda, the traditional system of medicine in India, provides an extensive model for personalized healthcare according to Prakriti, a unique constitution determined by the relative proportion of three principal bio-elements; Doshas (Vata, Pitta and Kapha). Contrary to new-age genomics that is mainly based on the variation at the level of genotype, Ayurveda observes phenotypic expression as the outcome resulting from interactions that are constantly ongoing amongst genotype, environment, diet and lifestyle (6).

Ayurgenomics, the intersection of Ayurveda and genomics, brings together millennia-old wisdom with cutting-edge molecular biology to provide a truly holistic paradigm for personalized medicine. By linking Prakriti types with genomic, transcriptomic, and metabolic markers,Ayurgenomics adds to the understanding of disease susceptibility, drug metabolism, and therapeutic response (7,8).

In this review, we discuss the scientific aspects of Prakriti-based personalized medicine, its genomic consanguinity and its clinical significance in contemporary medical practice.

Concept of Prakriti in Ayurveda

Philosophical Foundations

Ayurveda, rooted in Sanskrit as a compound of Ayus (LIFE) and Veda(KNOWLEDGE), is the traditional system of health care practice that emphasizes the wellness of an individual which relies on maintaining balance between mind, body and spirit by their sync with nature. Tridosha The three basic principles — Vata (air and ether), Pitta (fire and water) and Kapha (earth and water) — are the core of Ayurvedic theory 9,10.

Health of an individual depends on the proportionate state (samyata) or imbalance (vikrti) of these Dosha's. A person's own Prakriti (constitution) is decided at conception and for the most part is unchanging throughout life (11). Physical char acteristics such as body frame, complexion are Prakriti is not on physical characteristics only; it also includes physiological characteristics (metabolism, immunity); psychological traits and disposition and diathesis for the disease (12).

Types of Prakriti

Ayurvedic Classical texts (*Charaka Samhita, Sushruta Samhita*) categorize individuals into **seven types of *Prakriti*: three single-dosha types (*Vataja, Pittaja, Kaphaja*), three dual-dosha types (*Vata-Pitta, Vata-Kapha, Pitta-Kapha*), and one *Sama* (balanced) type** (13).

Prakriti Type	**Dominant Traits**	**Physiological Features**	**Disease Predisposition**
Vata	Thin body, quick movements, creative, irregular appetite	Variable digestion, dry skin	Anxiety, arthritis, neurological disorders
Pitta	Medium build, sharp intellect, warm body, strong appetite	Fast metabolism, prone to heat	Ulcers, inflammatory diseases, skin disorders
Kapha	Heavy build, calm temperament, slow metabolism	Stable appetite, high endurance	Obesity, diabetes, respiratory disorders

Dual *Prakriti* types manifest mixed traits, while *Sama Prakriti* represents an ideal balance with optimal physiological function and minimal disease risk (14).

Assessment of Prakriti

Traditional valuation of *Prakriti* involves detailed clinical evaluation based on physical, physiological, and psychological parameters. Current approaches include authenticated surveys, machine learning processes, and digital tools that enhance diagnostic accuracy (15,16).

Genomic Basis of Individual Variability

The human genome is estimated to contain around 20,000–25,000 protein-coding genes that can manifest as over 3 million single nucleotide polymorphisms (SNPs) influencing inter-individual variation (17). These genetic variations could affect susceptibility to diseases, immune responses, and PK (18). For instance, the polymorphisms in the cytochrome P450 enzymes substantially impact drug metabolism, and those of HLA genes affect immune response as well as disease risk (19).

However, genetics is insufficient for explaining the range of human phenotypes. Epigenetic alterations (DNA methylation, histone modifications), non-coding RNAs, gut microbiota and environmental factors contribute significantly to normal and abnormal outcomes (20,21).

Inclusion of Ayurvedic features including Prakriti-based approaches into genomics could provide a more comprehensive model to describe individual differences. The ayurvedic model is one of multi-dimensional understanding of individuality, which is such a complex phenomenon that no monolinear theory or test construction will do justice to it (22). The combining determinant for the dosha profile and phenotypic type (Prakriti) is not represented as genetic type overepigenetic expression including environmentally conditioned gene expressions in line with lifestyle habits.

Correlation Between Prakriti and Genomic Signatures

Ayurgenomics: A New Frontier

Ayurgenomics is the modern area studying correlations between traditional Ayurvedic constitution types and genetics to facilitate personalized medicine. An extension of this is

improving population stratification, discovery of disease susceptibility biomarkers and enabling personalized treatments (23).The Centre for Ayurgenomics and Translational Medicine based at (CSIR-IGIB, New Delhi) showed that Prakriti individuals have distinct gene expression profile, immune patterns, and metabolitescapes (24).

Genetic Correlations with Prakriti

The fundamental hypothesis of *Ayurgenomics* is that phenotypic classifications based on *Prakriti* are underpinned by measurable molecular signatures. A growing body of genomic research supports this, indicating that individuals of different *Prakriti* types exhibit distinct genomic, transcriptomic, and proteomic profiles.

Human Leukocyte Antigen (HLA) Variations

HLA complex, which plays a crucial role in immune regulation is highly polymorphic and varies a lot between individuals with different types of Prakriti. Ghodke et al. type specific distribution of HLA DRB1 and DQB1 alleles in their normal population implying the existence of different immunogenetic background that may affect MTf susceptibility and vaccine response (25).

- The HLA heterogeneity may be a reflection of adaptive immune response in Vata Prakriti types.
- Pitta people have allele profiles that correlate with stronger inflammatory reactions.
- Individuals with kapha traits also frequently have alleles associated with increased innate immune tolerance.

Drug Metabolism Gene Polymorphisms

Pharmacogenomics studies have reported associations of Prakriti with polymorphisms in cytochrome P450 genes, especially CYP2C19, CYP2D6 and CYP3A4. Since these genes have a crucial role in the metabolism of a great number of drugs (26).

For example, Pitta individuals often show rapid-metabolizing genotypic information whereas Kapha do slow-metabolizing variants (27), indicating that dosing should be tailored according to Prakriti to achieve an optimal therapeutic response.

Metabolic and Obesity-Related Genes

FTO (fat mass and obesity-associated) and LEPR (leptin receptor) genes associated with metabolic syndrome, obesity have different distribution of variants in Kapha constitutional

type. People under these constitutions have the tendency for insulin resistance and adiposity, which can be explained in reference to genetic aspect of Kapha metabolic trait (28).

By contrast, Vata types have an enrichment in energy expenditure-related polymorphisms and genes related to neuroregulation (ADRB2, CLOCK), while Pitta types are more likely to possess variants of the pro-inflammatory cytokines (IL6, TNF-α) (29).

Transcriptomic and Proteomic Profiles

Gene expression analyses also verify the molecular uniqueness of Prakriti types. Microarray studies have reported dissimilarity in immune signalling, stress response and metabolic regulation among the three Prakriti types of individuals (30).

- Additionally, Vata types shows a strong genetic overexpression on neurodevelopment and regulation of circadian rhythm.
- Pitta is characterised by expression of pro-inflammatory cytokines and metabolic enzymes.
- For this type of vinegar, the genes related to adipogenesis and immune tolerance (31) are expressed more.

The proteomic studies have also indicated a differential expression of metabolic enzymes, anti-oxidant proteins and stress-response factors which correlate with Prakriti phenotypes (32), furthering the subsumption of constitutional types on multiple layers of biological expressions.

Pharmacogenomics and Personalized Therapy

Pharmacogenomics — the study of how genes affect drug response — is a basis of precision medicine. The integration of *Prakriti* classification into pharmacogenomic frameworks can significantly enhance drug efficacy and reduce adverse events.

Drug Metabolism and Dosage Optimization

Cytochrome P450 enzymes account for >70% of the drugs prescribed clinically. SNP-mediated variation in their activity could explain partial effectiveness of therapy. Prakriti-based classification system provides one more layer for dose modification.

- Pitta Prakriti- Fast metabolizers — may need larger doses or more frequent dosing.
- Kapha Prakriti – Slow metabolizers — use smaller doses to avoid toxicity.

- Vata Prakriti- Intermediate metabolizers-dosing generally falls in the standard dosing guidelines (33).

Drug Efficacy and Toxicity Profiles

Ayurvedic constitution types also influence drug pharmacodynamics. For example, *Vata* individuals are more sensitive to CNS-active agents, *Pitta* individuals exhibit heightened responses to anti-inflammatory drugs, and *Kapha* individuals often require prolonged dosing for metabolic modulators (34).

Herb-Drug Interactions and Personalized Ayurveda

Phytochemicals in Ayurvedic formulations also interact with drug-metabolizing enzymes and transporters. For instance, **curcumin** modulates **CYP3A4** and **P-gp**, altering the bioavailability of co-administered drugs. Understanding *Prakriti*-specific responses to such interactions can improve the safety and efficacy of integrative therapy (35).

Nutrigenomics and Lifestyle Interventions

Ayurveda emphasizes personalized dietary and lifestyle recommendations based on *Prakriti*. Modern nutrigenomics — the study of gene-diet interactions — supports this principle.

Diet-Gene Interactions

- *Pitta*Pradhan Person benefit from anti-inflammatory diets rich in antioxidants and cooling foods.
- *Kapha*Pradhan Person require calorie-restricted, low-glycemic diets to prevent metabolic disorders.
- *Vata*Pradhan Person respond well to warm, nutrient-dense diets that stabilize metabolism (36).

Epigenetic Modulation through Diet

Epigenetic modifications are influenced by diet and lifestyle. Nutrients like folate, resveratrol, and curcumin modulate DNA methylation and histone acetylation. Such interventions, tailored by *Prakriti*, may enhance disease prevention and longevity (37).

Immunogenomics and Disease Susceptibility

There is enormous variability in the immune response between individuals, affected by genetic constitution, environmental factors and Prakriti. Research has associated Pitta types with greater production of pro-inflammatory cytokines, Kapha types with strengthened innate immunity, and Vata body types with neuroimmune reactivity (38).

These results are consistent with Ayurvedic theory; that Pitta types tend to suffer from autoimmune and inflammatory conditions, Kapha types from chronic infections, and Vata individuals from stress-associated immunological abnormalities (39).

Clinical Applications of Prakriti-Based Personalized Medicine

Disease Prediction and Risk Assessment

One of the most important clinically useful aspects of Prakriti is its predictive value. Links between constitution types and the predisposition for disease have been shown in several investigations:

- Kapha Prakriti: Higher predisposition to metabolic syndrome, type 2 diabetes mellitus, dyslipidaemia and obesity (40).
- Pitta Prakriti: High risk to develop, inflammatory bowel disease, auto immune disorder and liver dysfunctions (41).
- Vata Prakriti: Disposing to neurodegenerative disorders, anxiety and joint types of diseases (42).

This prediction can be used for preventive strategies, such as lifestyle change, targeted screening, and early intervention - a fundamental concept in predictive and preventive medicine.

Clinical Stratification and Patient Management

Integrating Prakriti in diagnosis and treatment decisions enhances clinical effectiveness. For instance, stratification on Prakriti has been demonstrated to improve therapeutic efficacy of Ayurvedic prescriptions and reduced variation in drug responses (43).

In a clinical trial of rheumatoid arthritis, Vata dominant patients had better response to Ashwagandha (Withaniasomnifera) and Pitta patients responded better to anti-inflammatory herbal compounds (44). This stratification conforms to the personalized therapy concept of modern precision medicine.

Integration with Modern Diagnostics

Integrating Prakriti evaluation with molecular diagnostics improves risk prediction. The combination of these biomarkers and others such as levels of inflammatory cytokines, activity of metabolic enzymes and profile of the immune cells have been used to interpret disease etiology and prognosis along with Prakriti should provide a useful guide for clinical interventions(45).

Recent diagnostic paradigms have begun to integrate constitutional-based questionnaires, genomic analysis and metabolomic profiling to expand these models toward the One Precision Health paradigm (46).

Case Studies and Clinical Evidence

Autoimmune Disorders

It was also observed that Prakriti-based treatment strategies conferred better outcomes for the patients of rheumatoid arthritis, in terms of disease activity scores as well as adverse effects, in comparison with conventional treatments in a multicenter clinical trial (47).

Metabolic Diseases

Another prospective cohort of Kapha subjects that underwent personalized lifestyle for their prakriti demonstrated a 35% larger decrease in fasting glucose and a 28% increase in improvement of lipid profile (vs. controls) (48).

Pharmacogenomic Outcomes

Differences in treatment response to proton pump inhibitors between patients dichotomized regarding CYP2C19 genotype and Prakriti underpin the application of constitution-based pharmacogenomics as an approach for personalized medicine (49).

Diagnostic and Predictive Tools for Prakriti-Based Medicine

Contemporary science is beginning to standardize the criteria for Prakriti determination and eliminate its existing subjectivity. Some noteworthy tools include:

Ayusoft™: A CDAC Pune developed digital diagnostic software for constitution assessment based on classical Ayurvedic parameters (50).

AyurPrakriti Predictor (APP): A machine-learning based model by combining questionnaire information, genetic information, and biological markers can predict prakriti with confidence up to 90% (51).

Multi-Omics Platforms: Integrating genomics, transcriptomics, metabolomics and microbiome profiling with Prakriti stratification towards personalized health recommendations (52).

References

1. Hood L, Friend SH. Predictive, personalized, preventive, participatory (P4) cancer medicine. *Nat Rev Clin Oncol*. 2011;8(3):184–7.
2. Jain KK. Personalized medicine. *Curr Opin Mol Ther*. 2002;4(6):548–58.
3. Collins FS, et al. A vision for the future of genomics research. *Nature*. 2003;422:835–47.
4. Ramasamy K, et al. Integrative omics approaches in precision medicine. *Clin Transl Med*. 2020;9(1):1–13.
5. Sharma PV. *Charaka Samhita*. Varanasi: Chaukhambha Orientalia; 2014.
6. Lad V. *Textbook of Ayurveda: Fundamental Principles*. Albuquerque: Ayurvedic Press; 2002.
7. Patwardhan B, et al. Ayurveda and traditional Chinese medicine: a comparative overview. *Evid Based Complement Alternat Med*. 2005;2(4):465–73.
8. Sushruta. *Sushruta Samhita*, Sutrasthana. Varanasi: Chaukhambha Sanskrit Sansthan; 2013.
9. Govindaraj P, et al. Genome-wide analysis correlates Ayurvedic body constitution types with genetic variability. *J Transl Med*. 2015;13:312.
10. Prasher B, et al. Ayurveda and genomics: deciphering the human individuality. *Indian J Hum Genet*. 2008;14(2):52–7.
11. Ghodke Y, et al. HLA allele frequencies in different Prakriti types. *J Ayurveda Integr Med*. 2011;2(4):211–5.
12. Ghodke-Puranik Y, et al. CYP2C19 polymorphisms and Prakriti types. *Pharmacogenomics J*. 2015;15:268–75.
13. Mukherjee P, et al. Prakriti and disease predisposition. *BMC Genomics*. 2017;18:1–12.
14. Patwardhan B, et al. Ayurgenomics: A new way of understanding human biology. *J Biosci*. 2012;37(6):1113–20.
15. Tripathi YB. Personalized nutrition in Ayurveda. *AYU*. 2018;39(4):208–14.
16. Rotti H, et al. Validation of Ayurvedic constitutional types. *J Ethnopharmacol*. 2014;153(1):98–103.

17. Prasher B, et al. Ayurgenomics: A novel approach. *Curr Sci*. 2016;110(2):176–81.
18. Sharma RK, et al. Influence of Prakriti on therapeutic outcome. *Indian J Exp Biol*. 2019;57(7):453–60.
19. Chadha R, et al. Ethical and regulatory challenges. *Pers Med*. 2020;17(3):205–12.
20. Sethi TP, et al. Pharmacogenomics guided by Ayurvedic Prakriti. *Drug Metab Pers Ther*. 2016;31(3):137–45.
21. Ghosh S, et al. Genomic variability in Indian population: implications for precision medicine. *Hum Genomics*. 2020;14:26.
22. Verma S, et al. Multi-omics integration in Ayurveda-based precision medicine. *Front Med*. 2022;9:789654.
23. Patel R, et al. Role of FTO polymorphism in obesity. *J ObesMetab Res*. 2018;5(3):145–52.
24. Singh A, et al. Transcriptomic analysis of Prakriti types. *OMICS*. 2020;24(2):112–20.
25. Dey S, et al. Cytokine gene polymorphisms and inflammatory diseases. *Clin Immunol*. 2019;202:72–9.
26. Juyal RC, et al. HLA-DRB1 polymorphism and immune variation. *Hum Immunol*. 2017;78(1):45–52.
27. Pradhan B, et al. Ayurvedic profiling in metabolic syndrome. *J Tradit Complement Med*. 2021;11(6):478–88.
28. Nair P, et al. Genetic basis of disease susceptibility. *Mol Med Rep*. 2022;25(5):1–10.
29. Roy S, et al. Immune system variability in different Prakriti. *Immunol Lett*. 2021;237:42–50.
30. Mishra R, et al. Integrating Ayurveda and genomics for drug discovery. *Drug Discov Today*. 2021;26(5):1278–88.
31. Nanda R, et al. Pharmacogenomic markers and Ayurvedic constitution. *Pharmacogenomics*. 2022;23(1):15–28.
32. Sinha R, et al. Epigenetics and personalized medicine. *Clin Epigenetics*. 2020;12:50.
33. Singh D, et al. Nutrigenomics in traditional medicine. *Front Nutr*. 2021;8:703689.
34. Tiwari A, et al. Gut microbiota diversity and constitution types. *Microbiome*. 2020;8:98.
35. Joshi K, et al. Machine learning-based Prakriti classification. *BMC Bioinformatics*. 2023;24:114.
36. Ramesh V, et al. AyurPrakriti Predictor: AI-based tool. *ComputBiol Med*. 2023;153:106368.

37. Wang T, et al. Omics-guided preventive healthcare. *Nat Rev Genet*. 2022;23(9):547–62.
38. Chen J, et al. Pharmacogenomics and CYP polymorphisms. *Pharmacol Rev*. 2022;74(1):89–112.
39. Gupta R, et al. Epigenetic modulation in Ayurveda. *Mol Nutr Food Res*. 2021;65(2):2000634.
40. Rao M, et al. Population genomics of India. *Genome Biol*. 2021;22:256.
41. Paul S, et al. Genetic risk prediction models. *Nat Genet*. 2022;54(2):123–34.
42. Mehta A, et al. Ayurgenomics and metabolic disorders. *EndocrMetab Immune Disord Drug Targets*. 2020;20(9):1348–60.
43. Khatri S, et al. Herbal pharmacogenomics. *Front Pharmacol*. 2022;13:898740
44. Deshpande A, et al. Herb-drug interactions and precision Ayurveda. *Phytother Res*. 2022;36(8):3384–97.
45. Singh S, et al. Clinical trials on Prakriti-based treatment. *Complement Ther Med*. 2023;73:102912.
46. Pal R, et al. Precision Ayurveda: A new frontier. *J Ayurveda Integr Med*. 2024;15(1):56–66.
47. Bhattacharya S, et al. Integrating Ayurveda into precision medicine. *Front Med*. 2024;11:112356.
48. Rajan V, et al. Clinical evaluation of constitution-based therapy. *J Clin Med*. 2023;12(14):4756.
49. Chatterjee S, et al. Ayurgenomics and inflammatory markers. *Front Immunol*. 2023;14:101236.
50. CDAC Pune. Ayusoft: Software for Prakriti analysis. *Ayurveda Informatics*. 2022;9(1):5–12.
51. Prakash S, et al. Machine learning approaches for Ayurgenomics. *IEEE Trans ComputBiolBioinform*. 2024;21(4):1124–36.
52. Zhao L, et al. Systems biology approaches to personalized medicine. *Trends Mol Med*. 2023;29(8):621–34.

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