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Review Article

Precision nutrition: An objective approach in metabolic disorder

Ravi Kant (MD) [1]
Poonam Yadav (MD) [2*]
Shruti Barnwal (MD) [3]

1. Division of Diabetes and Metabolism, General Medicine, AIIMS, Rishikesh, India
2. Centre of Excellence in Nursing Education and Research, AIIMS, Rishikesh, India
3. Depertment of Dermatology, Govt. Doon Medical college, Dehradun, India

*** Correspondence:**
Poonam Yadav, Centre of Excellence in Nursing Education and Research, AIIMS, Rishikesh, India

E-mail: drpoonam457@gmail.com

Abstract

Precision nutrition and personalized nutrition, deliver more preventive and practical dietary advice. Precision nutrition comprises dietary habits, food behavior, physical activity, deep phenotyping, metabolomics, microbiota, and nutrigenomics. Precision nutrition includes several clinical practice approaches, such as genetics, dietary habits, food behavior, physical activity, microbiota, and metabolome. With an overwhelming increase in obesity and associated metabolic disturbances, such as type 2 diabetes and cardiovascular diseases, precision nutrition represents a promising approach for preventing and managing metabolic syndrome. This review article highlights the concept of precision nutrition in clinical practice, especially in type 2 diabetes mellitus and metabolic disorders, to prevent and manage the disease. Precision nutrition is an emerging specialty of nutrition that produces a promising approach in clinical practice.

Keywords: Diabetes, Dietary approach, Metabolic disorders, Nutrigenomics, Precision nutrition.

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"**L**et the food be your medicine, and medicine be your food." This statement is attributed to Hippocrates, the father of Western Medicine, who outlines nutrition's impact on human health and disease. Precision nutrition also called personalized nutrition, is created to deliver more preventive and practical dietary advice (1). Precision or personalized nutrition aimed to create personalized nutritional guidance to prevent and treat nutrition-related diseases (2). Several factors, such as socioeconomic status, psychosocial factors, cultural variances, dietary patterns, and self-imposed diet, influence individual nutritional intake (3).

It emphasizes that the optimal diet is not the same for everyone; it aims to deliver tailored nutritional recommendations based on combined information from individuals' gut microbiota, genetic, physiological, and behavioral backgrounds. (3-8) Approaches to precision nutrition are genetics, dietary habits, food behavior, physical activity, microbiota, and the metabolome. A profuse rise in the prevalence of obesity and associated metabolic disturbances, such as type 2 diabetes and cardiovascular diseases, badly affects these patients' quality of life. However, precision nutrition is simultaneously rising as a boon with a promising approach for preventing and managing these disorders (9-14).

One of the goals of precision nutrition is to design a tailored nutritional prescription to treat metabolic disorders (15). Few public health workers have begun to see large-scale precision nutrition as a novel chance to provide the right dietary intervention to the right population at the right time. Large-scale precision nutrition is an individual-centered approach centered on behavioral modification on a large scale. However, it has a limited effect on obesity at a population level as it is not concerned with the population causes of obesity grown in obesogenic conditions (16).

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Although consistent evidence for behavioral interventions was also found that modified participants ' dietary intake and physical activities with a follow-up to 6 to 12 months were associated with modest reductions of risk factors such as blood pressure, total and LDL cholesterol, and adiposity measures (17). However, accurate and precise nutritional assessment is the key to measuring behavioral intervention's effect on dietary intake and physical activities and applying the concept of precision nutrition and the management of metabolic disorders.

Numerous scientific investigations into diets and nutrition offer vital information to communities and the general public. Every person has a unique biochemistry, metabolism, genetic makeup, and microbiome. In light of our unique eating patterns, body measurements, weight, cholesterol levels, and lifestyle, a specially made personalized nutritional plan can be developed to consider these things. So, this review is planned to explore the available literature on personalized nutrition and accurate and precise nutritional assessment methods to measure dietary intake and physical activities, apply the concept of precision nutrition, and manage metabolic disorders.

Components of precision nutrition

Precision nutrition must focus on the components below to provide a tailored nutritional prescription. Recent research in precision nutrition emphasizes the novel approaches of dietary habits assessment, food behavior evaluation, physical activity monitoring, and novel strategies connected to deep phenotyping, metabolizing, microbiota profiling, and nutrigenomics (15). With a comprehensive approach of all these components, the best nutrition approach can be suggested to prevent and treat metabolic disorders, one of the precision nutrition goals (figure 1).

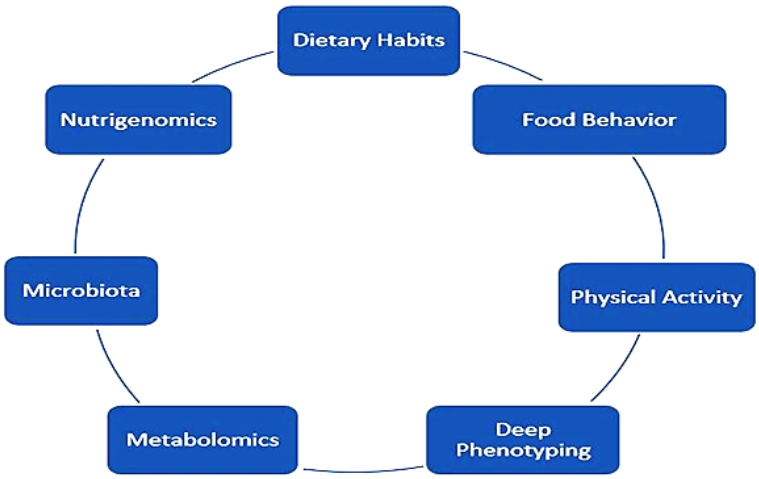

Figure 1 Components of precision nutrition

Assessment of precision nutrition

Precision nutrition can be assessed through classical, technological, and biochemical measures. Precision nutrition components incorporate dietary habits assessment, food behavior evaluation, physical activity monitoring, and novel strategies connected to deep phenotyping, metabolizing, microbiota profiling, and nutrigenomics (1).

Eating behavior

The limitations of assessing food intake and particular nutrient component intake require analytical determinants that can objectively and accurately measure nutritional components (18). Assessment of eating behavior can be done subjectively and objectively with the aim of evaluation of dietary intake (e.g., food consumption, use of nutrient supplements) and eating behavior for that is necessary to collect, analyze, and store data such as dried blood spot testing, saliva swabs, stool kits, shipment material, local pharmacy networks, accelerometers, smartphone and other digital technologies, and biobanks (19, 1).

Subjective dietary assessment methods

a.Food Frequency Questionnaire (FFQ): The food Frequency Questionnaire is a checklist of foods and beverages with a frequency response section for patients to report on each item consumed within a specified period. Semi-quantitative FFQs collect partial information as a choice of portion sizes. The calculation for nutrient intake can be assessed through electronic programs by measuring supplements in a serving of that food (20).

b. 24-h dietary recall (24H): A 24-hour diet recall is a method that includes a structured interview in which respondents are asked to recall all food and drink consumed in the last 24 hours. The main feature is that when

appropriate, the respondent is asked for more detailed information than first reported. For example, Dietary recalls first ask for foods and beverages, then questions on dietary supplements. Besides, other detailed information, such as time of day and food source, size of each food item, and beverage, is noted (21).

c.Dietary record (DR): A diet record (also called a food diary) is a self-reported and open-ended assessment method in which the respondent records all the foods and beverages consumed within a specific period. Respondents must be trained and motivated before administering this method to get accurate information (22, 23).

d.Dietary history: A dietary history is any retrospective dietary assessment using a structured interview that asks the respondents to report past diet, including habitual food items and dietary behaviors (such as skipping breakfast and dieting). The technique uses open-ended questions to note foods and drinks consumed at each mealtime with a specification of the amount followed by a 'cross-check' about habitual intake in the past 3, 6, or 12 months. Portion size information is obtained with the use of photographic aids. The method requires a face-to-face interview; otherwise, adjusting for the respondent's telephonic interview or self or computer completion is difficult (24).

Objective assessment of eating behavior

a. Fine-Tuning Adherence
b. Universal Eating Monitor (UEM)
c. Automatic Ingestion Monitor (AIM)
d. Remote Food Photography Method (RFPM)

a. **Fine-Tuning Adherence:** Subjective dietary assessment methods have many limitations, such as recall bias, high cost, and time to assess food behavior (20). It is necessary to have a reliable dietary assessment method as a key for explaining diet-induced metabolic issues. Two novel dietary adherence methods are the Mediterranean Diet Adherence Screener (MEDAS) and the Mediterranean Lifestyle Index (MEDLIFE) (25, 26). The MEDAS includes a simple 14-point-instrument to overpower the time-consuming classical FFQ. The MEDLIFE index is the first to quantify other variables beyond food consumption that are part of the Mediterranean lifestyle (27).

b. **Universal Eating Monitor (UEM):** The universal eating monitor (UEM) is a table-embedded scale that measures grams ingested over time. It has been used to test the effect of anorectic drugs and behavior changes, such as slowing eating. It can also study the association between demographics and body weight. A single bite can only be measured with the scale after carefully removing a single bite of food, consuming it entirely, and waiting for a minimum before the next bite. Limitations incorporate requiring a particular utensil, refusing beverages, and constraining nourishment decisions (figure 2) (28).

Figure 2. Universal eating monitor (28).

c. Automatic Ingestion Monitor (AIM): An automatic ingestion monitor (AIM) is a novel wearable sensor system for target checking food intake in free living. AIM's wearable sensor arrangement comprises four essential parts: a jaw movement sensor, a remote module, an RF transmitter of the HtM sensor, and an Android cell phone (figure 3) (29).

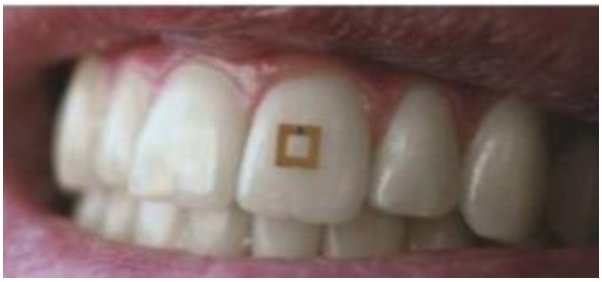

Figure 3 Automatic Ingestion Monitor (29).

d. **Remote Food Photography Method (RFPM):** A new dietary assessment method, called the Remote Food Photography Method (RFPM), offers an option in contrast to conventional methodologies. Rather than talking to individuals or requesting that they record what they eat or drink, the RFPM depends on pictures taken from camera-empowered advanced cells. Patients do not need to go to the research center or invest energy in recording the dietary data. They snap a photo on cell phones during eating or drinking. Food images contrast with nourishment photos of specific segment sizes, and the calories and significant nourishment segments are determined by registered dietitians (figure 4) (30).

Physical activity

In such a manner, together with authentic learning of dietary habits, food practices, genetics, and gut microbiota factors, just as detailed metabolic phenotyping, precision energy expenditure measurements, including resting energy expenditure (REE), the thermic impact of food and activity

related physical activity ought to be viewed as when implementing precision nutrition approaches, as depicted in (figure 5). Regarding multidimensional portrayal of physical activity (including components, for example, occupational, physical activity, sedentary time, and recreation activities) has been recently proposed as an approach to give a comprehensive picture of physical activity, decreasing the inclination related to a unidimensional approach exclusively based on physical activity (31).

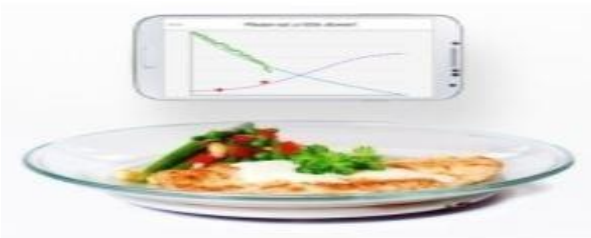

Figure 4. Remote food photography method (30).

Methods to assess physical activity

It is aimed to measure the physical activity level and estimate energy expenditure.

Online questionnaire: This is the subjective method for assessing physical activity. A questionnaire is available online for the assessment of physical activity. The patient will be asked to fill out a questionnaire related to the physical activity performed by them.

Wearable/portable devices: It is the objective method for assessing physical activity (figure 6**).** These are physical activity monitoring devices that explain step count. Its primary purpose is to maintain health and fitness. Accelerometers were first developed in the 1980s. This device has been used on a large scale for measuring physical activity. Recently developed accelerometers can display activity patterns (i.e., locomotive or non-locomotive movements) and estimate physical activity and energy expenditure. Tools that are required to collect data can be linked with electronic health records, biomedical laboratories, artificial intelligence, etc. (32).

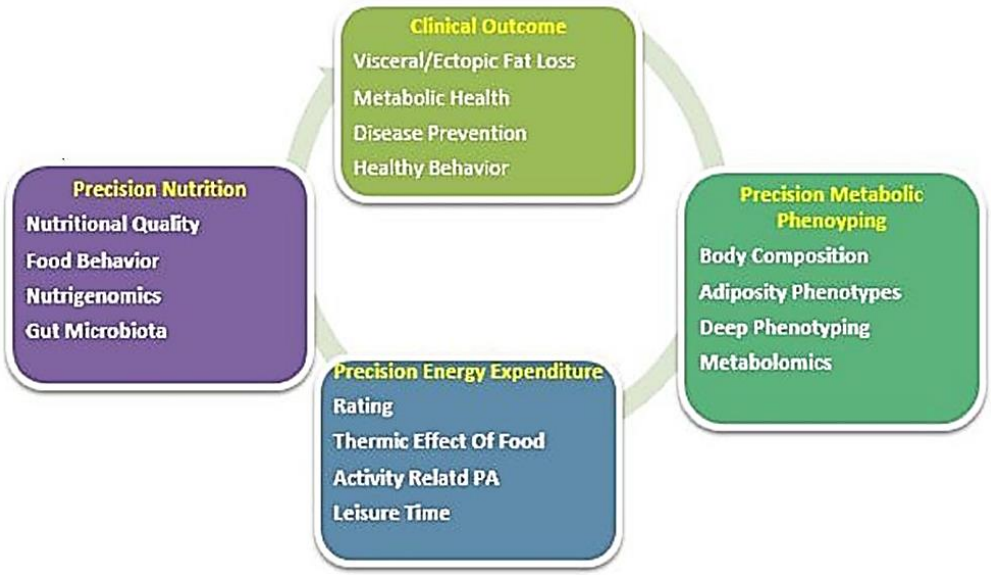

Figure 5. Physical activity and precision medicine

Deep phenotyping

Deep phenotyping is described as the comprehensive analysis of the individual components of the phenotype (33). According to their basic biological mechanisms, precision nutrition must understand the precise relationship between genes, phenotypes, and diseases (34). Diabetes and metabolic diseases are examples of imprecise phenotypes (35). Deep phenotyping aims to assess body composition, nutritional status, and other risk factors for diet-related diseases with anthropometric measurements.

a. Bodyweight measurement

Estimating body weight is the most widely recognized way for individuals to assess changes in their bodies, particularly when planning to see changes because of appropriate eating and exercise (36).

b. Body fat estimation

Several techniques are used to measure body fat. DEXA, hydrostatic (underwater) weighing, bioelectrical impedance, and skin fold caliper measurements. However,

hydrostatic (underwater) weighing is the best method of body fat estimation (37).

c. The skinfold thickness

Seven sites need to be measured to measure the skinfold thickness, such as the abdominal site, triceps site, chest site, midaxillary site, subscapular site, supra iliac site, and thigh site (36).

d. Girth measurements

Preferably, Mayo Tape measures neck girth, shoulder girth, chest girth, upper arm girth, waist girth, hip girth, thigh girth, and calf girth. Clinical chemistry will be done from various bio-samples (e.g., plasma, urine, saliva) to assess visceral fat distribution (36).

Nutrigenomics

Nutritional Genomics is centered on the interaction between nutrients and the genome, which involves Nutrigenetics and Nutrigenomics. The effect of nutrients on f gene expression is called nutrigenomics. In contrast, the effect of gene variants on nutrients and developing nutraceuticals is called nutrigenetics (38). Nutrigenomics points to identifying the influence of macronutrients and micronutrients on the genome and searching for the interaction of genes and nutrients and their influence on health (39, 40). Nutrigenetics focuses on exploring the influence of an individual's genetic background on a diet (39). The genetic polymorphism in the CYP1A2 gene influences an individual's caffeine response (41). This gene encodes for an enzyme that demethylates caffeine, and specific gene variants also quickly demethylate caffeine (42). It depicts an unsuitable diet for any individual genotype that could be a risk factor for a genetic disease in developing science (43). Nutritional Genomics aims to view genetic variants associated with diet-related diseases and responsive to dietary changes with DNA extraction and genotyping of selected loci from whole-blood Samples. For example, soy isoflavone ingestion significantly impacted several metabolic pathways with energy metabolism and osmolyte fluctuation (44). Nutrigenomics aims to integrate a personalized nutritional omics profile that incorporates the individual's microbiome and constitutes the "gutome." (45).

Figure 6. Wearable/portable devices (32)

Microbiomics

The gut microbiota performs integral functions that the body is incapable of performing. It enhances gut maturation, improves the immune system, protects against pathogens, and affects metabolism and brain activities (46). Of the seven phyla that comprise the intestines' commensal bacteria, two phylogenic types dominate *Firmicute* and *Bacteroidetes* (47). Most gut species perform a beneficial role in human health by keeping the harmful microbiota in check (48). Each nutrient type, such as carbohydrates, lipids, and protein, affects the microbiome differently in animal studies, such as diets rich in protein and animal fat, leading to Bacteroides' expression in the gut microbiome (49). Excessive intake of specific nutrients leads to derangements in microbial composition; for example, mice have a decrease in *Bacteroidetes* while increasing both *Firmicutes* and *Proteobacteria* when fed with a high-fat diet (50). Besides, an animal-based diet decreases the levels of *Firmicutes* and increases the abundance of bile-tolerant microbes in healthy humans (51). Dietary fiber also affects the composition and metabolome of the microbiome (52). It is a recognized strategy to modulate the gut microbiota with dietary fibers, probiotics, and prebiotics to prevent the disease and stay healthy (53). Dietary habits seem to influence the gut microbiota's quality in the long term and its efficacy in the human body. Hence, healthy dietary patterns ensure richness of dietary fiber, healthy fats such as MUFAs and PUFAs, and plant-derived proteins promote diversity in gut microbiota. However, as countries become more modern and people consume the available

food for consumption, taste satisfaction, and easiness at the cost of nutritive value affect health (46). Microbiomics understand the interplay between diet and gut microbiota. Feces are collected to sequence the microorganisms in the gut for microbial profiling.

Metabolomics

Metabolomics targets the analysis of large numbers of small molecules such as amino acids, carbohydrates, lipids, nucleotides, and their metabolites in cells, tissues, and biological fluids and detects them in cerebrospinal fluid (CSF), plasma, urine, and saliva quantitatively (54, 55). Metabolomics is a component to explore food's impact on the individual's health status. Identifying inter-individual variations and food-derived biomarkers in metabolizing similar nutrients in health and disease conditions (56). It directly expresses biochemical reactions with the genome, transcriptome, and proteome. It also involves environmental influences within an entire organism, such as diet patterns, lifestyle, and disease conditions (55, 57). Metabolomics aims to understand how the body metabolizes/uses nutrients. Methods can be complex chemical analyses from biosamples (e.g., serum, plasma, urine) using nuclear magnetic resonance spectroscopy and mass spectrometry-based techniques (1). The metabolites directly indicate biochemical or enzymatic activity and correlate with the biochemical changes within an individual's phenotype (58). Biochemical assessment is a significant aspect of the nutritional assessment for all patients on nutritional support. The biochemical assessment aims to assess general nutritional status and to identify specific nutritional deficiencies. It focuses on serum protein measurements, serum micronutrient levels, serum lipids, and immunological parameters in the laboratory. The most frequently used laboratory tests are an estimation of serum iron, total iron-binding capacity, albumin, prealbumin, hemoglobin, CD4, CD8, virus load of HIV, cholesterol, triglycerides, renal function, and liver enzyme levels, fasting glucose, magnesium, vitamin levels, trace elements (59).

International Society of Nutrigenetics/Nutrigenomics

The International Society of Nutrigenetics/Nutrigenomics (ISNN) aims to enhance the understanding through scientific research on genetic variation, dietary response, and nutrients' role in gene expression (60).

ISNN describes the following three levels of Precision Nutrition:

1.**Stratified nutrition** involves stratifying conventional nutritional guidelines into population subgroups by age, gender, and other social determinants.

2.**Individualized nutrition: -** Individual approach issues from deep and refined phenotyping.

3.Genotype nutrition: -A genetic-directed nutrition based on rare genetic variants having high penetrance and impact on individuals' response to particular foods (3).

It targets to integrate and ensure that healthcare professionals, such as physicians, dietitians, genetic counselors, and pharmacists, have sufficient knowledge of nutrigenetics and nutrigenomics concepts. It will help them apply that knowledge at the most appropriate level of care to attain precision nutrition, which incorporates phenotypical, genotypical, metabolic, and environmental factors (61-63).

Precision Nutrition and Type 2 diabetes mellitus

Around the globe, men and women have gained weight due to faulty dietary patterns and decreased physical activity (64). A higher body mass index is the most substantial risk factor for diabetes, but Asians tend to have diabetes at lower BMI levels (65). Shreds of past evidence have also shown the gene environment's significant influence on obesity. Data from previous trials suggested that genetic variants could modify the adiposity and metabolic response to low-calorie weight-loss diets, especially with obesity and type 2 diabetes (6). An imbalance between energy expenditure and high energy uptake in the diet is the predictor of the obesity epidemic, leading to diabetes mellitus (66).

Several studies reported that body weight, body mass index, waist circumference, body fat %, and waist-to-hip ratio are the markers of insulin sensitivity in diabetes patients (67-69). Waist to Hip Ratio and body fat % were also observed as the differential markers of insulin sensitivity in patients (type 2 diabetes mellitus) of both genders (11). In the past few decades, evidence from prospective observational studies and clinical trials has joined to help the significance of individual supplements, nourishments, and dietary examples in the anticipation and the executives of type 2 diabetes. The nature of dietary fats and food starch is more essential than the amount of these macronutrients. Diets rich in entire grains, natural products, vegetables, and nuts, moderate in liquor utilization, and lower in refined grains, red/prepared meats, and sugar-improved drinks have been shown to diminish diabetes complications and improve blood glucose and lipids in diabetes patients (70). A few energizing dietary examples accentuating the general eating regimen quality can be adjusted to suitable individual and social nourishment inclinations and calorie requirements for weight control and diabetes aversion and the board. Although considerable progress has been made in creating and implementing evidence-based nutrition recommendations, developed

nations, coordinated worldwide efforts, and strategies are justified to lighten regional disparities (71). By tailoring dietary recommendations to a combination of a person's genetic background, metabolic profile, and environmental exposures, precision nutrition aims to prevent and manage diseases. Nutrigenomics studies have distinguished genetic variations that impact the metabolism of nutrients and foresee the individual variation in response to dietary recommendations (43). Significant dietary interventions have effectively modified gut microbiota, food metabolism, and glycemic control (53).

Metabolomics has uncovered metabolomic fingerprints of food and nutrient utilization and revealed new metabolic pathways possibly changing by eating patterns. Wearable devices favor continuous evaluation of diet patterns and improve glycemic control and diabetes management with feedback (29). Recent advances and combinations of technologies can boost the thought of precision nutrition in clinical practice and give direction to personalized nutrition to successfully prevent and manage type 2 diabetes and metabolic disorders (4). Precision nutrition is a significant part of precision medicine. It is important in preventing and treating type 2 diabetes mellitus and other metabolic disorders. The management of diabetes mellitus includes nutrition, exercise, and hormonal therapy; hence, nutrition is a major concern in clinical practice (5).

Challenges associated with the implementation of precision nutrition

The lack of knowledge, negative beliefs, poverty, lack of spousal support, and time constraints were key challenges to the precision nutrition intervention. Lack of awareness and unfavorable beliefs/misconceptions also create hurdles to its implementation (72, 73). Unaware of the value of a balanced diet and lacking knowledge about it emerged as a major barrier under this subtheme. The literature review also noted a significant drawback: the absence of inclusivity for all social categories (73, 74). Therefore, willingness to change behavior may impact nutrition intervention use more than availability and accessibility. This means that those who conduct nutrition programs should also work to raise awareness and alter eating habits. Participation in the integrated nutrition intervention is negatively impacted by unfavorable attitudes, such as the idea that nutrition interventions are only for the underprivileged or malnourished and a sense of embarrassment about taking part in such programs (75, 76). Additionally, several studies have demonstrated how community attitudes, cultural effects, and religious influences all play a role in how nutrition intervention is used. These obstacles may prevent them from consuming nutritious food that is balanced and varied, which may have an impact on their nutritional status (72-77).

Conclusion

Nutritional assessment is a significant determinant in diagnosing and managing most metabolic disorders. Precision nutrition is a personalized approach with a way forward for managing most diseases and associated complications. Precision nutrition can be assessed through classical, technical, and biochemical methods. Although its application is difficult in clinical practice, its comprehensive approach provides sound scientific ground for combating the increasing prevalence of diabetes and metabolic disease. Conclusively, precision nutrition is a boon with a promising approach for preventing and managing these disorders in clinical practice. Patients' everyday existence is also influenced by personalized nutrition. Interacting with interfaces like smartphone apps that can give regular dietary support or nutritional guidance will be more comfortable than having to bring up the subject during consultations with specialists like doctors or nutritionists. Finally, before full confidence that precision nutrition can solve the issues with health and nutrition, research is needed to examine its efficacy, capacity to influence behavior, cost-benefit assessments, and the specific role of precision nutrition by percentage in the overall management plan.

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