Section A -Research paper

Insights into Consumer Acceptance and Usability of Genetic Testing for Personalized Nutrition in the Management of Obesity among Indians

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Abstract

Nutrients are one of the environmental factors that constantly interact with the human genome. Various nutrients present in the food acts as cofactors in various metabolic pathways, thus seem to influence the processes involved in DNA repair and metabolism. The individual's genotype determines the response to a particular nutrient whereas the nutrient present in food influences the development of phenotype. In the recent years, there has been a growing interest to utilise the precision nutrition approach for the prevention, management and treatment of obesity, which takes into consideration the interaction between food and the genome. It is quite evident that awareness and popularity about genetic testing for personalised nutrition is gaining momentum. Consumer attitudes and perceptions towards genetic testing to determine the risks of a predisposition to various diseases have already been examined by several studies, consumer acceptance of personalised nutrition have not been studied in the Indian population till date. The responses towards perceived advantages of receiving DNA based dietary advice were ease of understanding and specificity of the diet advice, which was the most frequently reported theme (57.5%), followed by more personalised and enjoyable (22.4%) and reduced costs due to disease prevention (20.1%). It can be concluded that individuals were optimistic and perceived many advantages of nutrigenetic testing. Our study supports that the population is optimistic and willing to adopt genetic tests for personalised nutrition recommendations. We compared the difference in the phenotype between participants receiving nutrigenetic recommendations vs generic standardised recommendations. BMI and waist circumference at 30 days, 60 days, 90 days were measured and they were followed up at 120 days. After 120 days of follow-up

individuals in the intervention group were more likely to have maintained some weight loss (82%) than those in the comparison group (21%) .

Keywords: *Genetic testing, Personalized nutrition, Consumer acceptance, risk vs benefit, Nutrigenetic testing.*

1.1 Introduction

Obesity is a complex, multifactorial preventable disease, characterised by positive energy imbalance resulting in excess body weight. The growing epidemic of obesity has coincided with a distinct shift in the environment, such as sedentary life, physical inactivity, poor sleeping habits, stress, pollution, unhealthy dietary patterns, eating behaviour. (Townshend, *et al*., 2017).

The completion of the human genome project in 2003 accelerated the advancements in the field of genetics and utilisation of the genetic information in clinical settings. Similarly, Genome- Wide Association Studies (GWAS) (2007) contributed to the identification of specific genetic variations associated with certain diseases. Currently there are more than 740 genes associated with obesity (Akiyama, *et al*., 2017) (Turcot, *et al*.,2018). Single Nucleotide Polymorphisms, SNPs are the most common genetic variation, that occur throughout the human genome and found in at least 1 % of the population.

With the discovery of genetic variants associated with obesity, there is an increased use of genetic information to identify individuals at risk of obesity. Knowing an individual's genetic susceptibility for obesity will help to identify who is at more risk for gaining weight and this would allow for earlier interventions in the prevention of obesity in an effective manner. (Loos, *et al*., 2022).

According to the 12^{th} update of the human obesity gene map (2005), nearly 253 QTLs (Quantitative Trait Loci) have been identified for obesity related phenotypes from large scale genome-wide association studies (Rankinen, *et al*.,2006). Several research studies have established not only the genetic basis for obesity and body composition but also provided the evidence for an individual's response to weight loss or gain. To name a few genes that are involved in the molecular pathways linked to obesity are those affecting neural regulation of feeding and body weight- BDNF, MC4R, NEGR1, genes associated with fasting insulin secretion and action, energy metabolism, lipid metabolism, and/or adipogenesis - FTO, TCF7L2, IRS1, FOXO3, RPTOR, PTBP2, MAP2K5, MAPK3 (Mahmoud, *et al*., 2022).

Such information from several research studies has helped to clarify molecular mechanisms involved in obesity. Emerging evidence also suggests that genetic variants may have an impact on the efficacy of the behavioural weight loss interventions (Thaker, *et* al.,2017) These studies have enabled to gain an in-depth understanding about the molecular mechanisms involved in obesity and provides new insights into the genetic prediction of weight loss. This study is first of its kind in India, based on the results of the previous research studies, attempts to determine the consumer acceptance and usefulness of nutrigenetic testing in designing personalised diet recommendations and its potential in management of obesity.

1.2 Methods

1.2.1 Sampling Method

A base line survey was conducted to determine the consumer acceptance on nutrigenetic testing. Interview method was used to collect data from the consumers who had gone through personalised nutrigenetic testing for weight loss. About 500 healthy adults participated in the study in the interview method. A validated survey questionnaire was used to determine the consumer acceptance of nutrigenetic testing for personalised nutrition among Indians. A comparative analysis was done to examine the usefulness of nutrigenetic testing. Participants were divided into nutrigenetic and non- nutrigenetic group. The non-nutrigenetic group (n=54) received a standardised diet of 1500 kcal for losing weight whereas the nutrigenetic group (n =52) received personalised diet recommendations based on the nutrigenetic test. 15 genetic variants in 10 genes involved in body weight regulation were selected for the nutrigenetic testing.

Fig.1 Two groups, nutrigenetic group and non- nutrigenetic group were selected for the study and standard diet was modified based on the genetic results for the individuals in the nutrigenetic group. A baseline diet of 1500 kcal were given to all the study participants.

1.2.2. List of polymorphisms and their genotype frequencies

In this study, 15 genetic variants present in 10 genes were tested and analysed. Information pertaining to the list of genes, SNP id and their genotype frequencies are presented in table 1**.**

Table 1. List of Polymorphisms and their genotype frequencies

Gene	SNP	Major/minor allele	Major allele homozygote	Heterozygote	Minor allele homozygote	HWE p value
PPARGC1A	rs8192678	C/T	48.7	33.3	17.9	2.7
AG	rs699	A/G	42.9	42.9	14.3	0.18
FTO	rs9939609	T/A	46.5	44.2	9.3	0.03
LIPC	rs1800588	C/T	41.9	44.2	14	0.07
MC4R	rs17782313	T/C	28.6	64.3	7.1	5.07
CD36	rs1761667	G/A	47.6	38.1	14.3	0.85
FTO	rs8050136	C/A	44.2	48.8	7	0.76
FTO	rs11076023	A/T	38.1	47.6	14.3	0.03
ADIPOQ	rs17300539	G/A	79.1	20.9	0	0.59
PPARG	rs1801282	C/G	69.8	25.6	4.7	0.54
CD36	rs1984112	A/G	42.9	42.9	14.3	0.19
CD36	rs1527479	T/C	50	38.1	11.9	0.49
MTHFR	rs1801133	G/A	90.7	9.3	0	0.1
FTO	rs3751812	G/T	48.8	44.2	7	0.22
APOA5	rs662799	A/G	67.4	30.2	2.3	0.11

Saliva sample was collected using the saliva sample collection kit for the nutrigenetic testing along with their diet and lifestyle information using a standardised questionnaire. The collected saliva samples were then tested and analysed using Next Generation Exome sequencing method. One-way ANOVA test was used to compare the baseline information based on the age, weight and BMI kg/m^2 . One-way ANOVA test was carried out to test the null hypothesis of baseline information between the nutrigenetic and the non-nutrigenetic group.

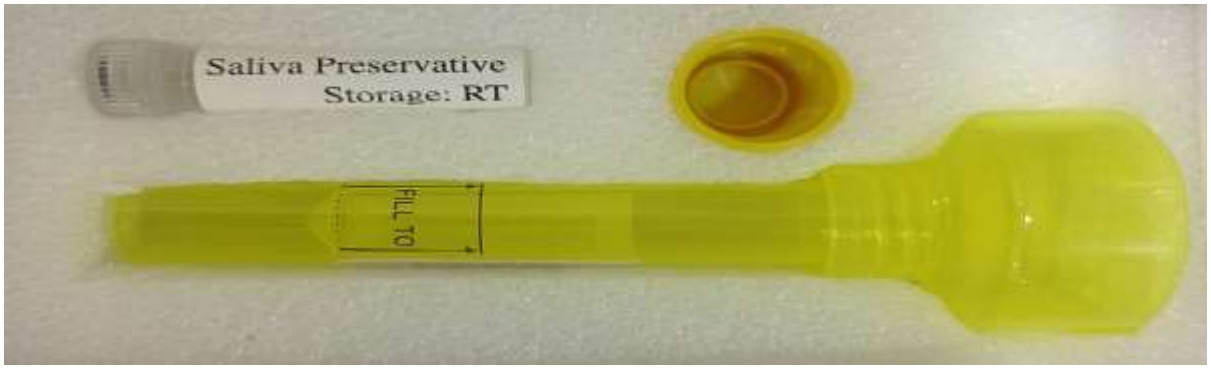

Fig.2. Saliva Sample Collection Kit used for Nutrigenetic Testing

1.3 Results and Discussion

1.3.1 Characteristics of participants of the baseline survey

This section presents information about participants who took part in the baseline survey

Table.2 Characteristics of individuals who participated in the baseline survey

Characteristics	**Sample Distribution (N = 500)**	**%**	***p*** [1]
Gender			
Male	241	48.2	0.0001
Female	259	51.8	
Age			
18-29 years	84	16.8	0.0001
30-39 years	110	22	
40-49 years	123	24.6	
50-59 years	76	15.2	
60-69 years	52	10.4	
Above 70 years	55	11	
Educational Qualifications			
Graduation Degree	126	25.2	0.04
Post- graduation Degree	181	36.2	
Professional Degree	174	34.8	
Doctoral Degree	19	3.8	
Occupation			
House wife	58	11.6	0.0001

Business	167	33.4	
Private Job	126	25.2	
Government Job	51	10.2	

1 Chi-square test was used to assess differences between subgroups

Characteristics of individuals who participated in the interview session are shown in Table 2. 48% of the participants were males and 52% were females. The mean age was 38.3 ± 14.9 years. The majority of the participants were from the age group between 40- 49 years.

1.3.2 Factors influencing motivation to adopt personalised nutrition advice

The survey questionnaire included questions to assess the factors that influence motivation to opt for personalised nutrition advice.

Table.3 Motivation to adopt personalised nutrition advice

	Motivation Factor of consumers	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree	Mean response ± SD
	Numerical Value	1	2	3	4	5	
1.	Personalized nutrition makes me able to live longer in good health.	9	7	45	260	179	4.43 ± 0.79
2.	Personalized nutrition can help disease prevention.	5	18	6	186	285	4.17 ± 1.05
3.	If I weigh up the benefits and drawbacks of genetic-based personalized nutrition, I can see more benefits.	4	8	42	164	282	3.98 ± 1.05

Three statements namely, "Personalized nutrition makes me able to live longer in good health", "Personalized nutrition can help disease prevention", "If I weigh up the benefits and drawbacks of genetic-based personalized nutrition, I can see more benefits" were included in the survey questionnaire to assess motivation to adopt personalised nutrition advice based on genetic testing. These statements were used to understand the motivation factors to adopt the personalised nutrition advice. Majority of them (57%) chose " personalised nutrition could help disease prevention' (Mean response ± SD, 4.43 ± 0.79), followed by 'can see more of benefits over drawbacks of genetic based personalised nutrition" (56.4%) and 'personalised

nutrition makes me able to live longer in good health' (52%)(Mean response ± SD, 4.17 ± 1.05).

1.3.3 Perceived advantages and disadvantages of nutrigenetic testing

Participants of the baseline survey was asked about the advantages and disadvantages of receiving personalised dietary advice based on genetic test. Statements such as " personalised nutrition is easier to understand and specific than general diet advice", "Genotype-based personalized nutrition advice is much Personalized & more enjoyable" and "Costs of diseases" can be prevented by personalized nutrition.

Table.4 Perceived Advantages and Disadvantages of Nutrigenetic Testing

Advantages	%	Disadvantages	%
Personalised nutrition is easier to understand and specific than general diet advice.	57.5	**Personalized nutrition is much more time-consuming.**	34.3
Genotype-based personalized nutrition advice is much Personalized & more enjoyable.	22.4	**Personalised nutrition can add cost by advising to consume specific food.**	45.7
Costs of diseases can be prevented by personalized nutrition.	20.1	**Personalised nutrition advice is not feasible because it is difficult to prepare different foods for different family members.**	20

The advantages and disadvantages perceived by the consumers about receiving personalized dietary advice based on genetic makeup are presented in Table 4. It was found that participants felt that ease of understanding and the specificity of the dietary recommendations were perceived as the most advantageous in terms of nutrigenetic testing (57.5%).

1.3.4 Comparison between nutrigenetic group and non-nutrigenetic group

BMI and waist circumference of all the participants in the study were measured and recorded at regular intervals. These measurements were recorded at 30 days, 60 days, 90 days and 120 days respectively. Significant reduction in waist circumference were observed at 60 days and 90 days compared to the non- nutrigenetic group. The odds ratio was 5.74 ($P < 0.003$) and

4.98 ($P < 0.007$) respectively. Similar results were observed in the BMI reduction in nutrigenetic group compared to the non-nutrigenetic group.

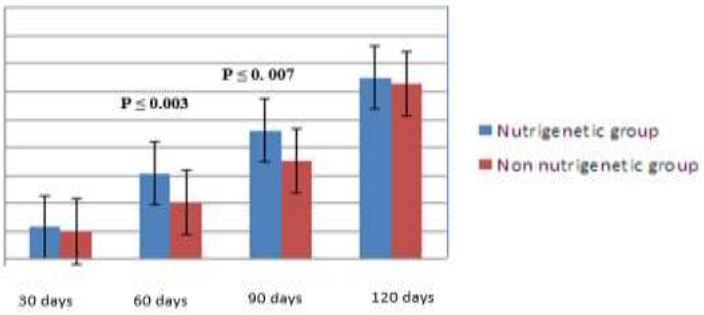

Figure.3 Comparison of change in waist circumference among nutrigenetic and non-nutrigenetic group

1.4 **Conclusion**

The findings of the study further support that the participants of the study is generally optimistic regarding the use of nutrigenetics in health care practice. Several risks have been identified in relation to the genetic testing for personalised nutrition by the consumers, which needs to be adequately addressed through effective communication to overcome individuals' fear while designing and implementing gene based personalised nutrition services. A realistic and pragmatic approach to ensure the consumers are motivated to engage these services. Another finding of the study reveals the use of nutrigenetic testing to be a useful dietary assessment tool in weight management and long-term compliance of dietary changes. Adding a personalised aspect to weight loss program not only improves motivation and compliance but also helps to optimise the intake of macro and micronutrients of an individual.

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Author Contributions

Janani Tamilvanan was responsible for the conception, writing, proofreading, editing of the article writing and tables/figure preparation. Kalpana CA is the corresponding author of this article and was involved in writing and reviewing.

Conflict of Interest

The author(s) declare(s) that there is no conflict of interest.

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