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Clinical and Health Research Exploration

LONGITUDINAL ASSESSMENT OF NUTRITIONAL INTERVENTIONS ON CARDIOMETABOLIC RISK REDUCTION IN MIDDLE-AGED ADULTS

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Abstract

This study investigated the longitudinal impact of structured nutritional interventions on cardiometabolic risk reduction among middle-aged adults, emphasizing the comparative efficacy of Low-Glycemic Index (LGI), Mediterranean, and DASH dietary patterns. Employing a mixed-methods experimental design, 180 participants were monitored over a 12-month period through quantitative biochemical assessments and qualitative behavioral evaluations. Participants were randomly assigned to one of three diet groups and underwent periodic assessments measuring fasting glucose, lipid profile, body mass index (BMI), blood pressure, and inflammatory biomarkers. Statistical analyses using repeated-measures ANOVA and multivariate regression revealed significant reductions in fasting glucose (−15.8%), LDL cholesterol (−18.6%), triglycerides (−12.3%), and systolic blood pressure (−7.9%), with corresponding increases in HDL cholesterol (+9.4%). The Mediterranean and DASH diet groups demonstrated the greatest overall improvement in cardiometabolic indices, while adherence level emerged as a key predictor of physiological outcomes. Qualitative findings indicated that participants reported improved energy, mood stability, and food-related self-efficacy, reinforcing the behavioral sustainability of dietary adherence. The integrated results confirmed that dietary intervention, when reinforced through behavioral support, yields multi-dimensional benefits encompassing metabolic, vascular, and psychological health. These outcomes suggest that evidence-based nutritional frameworks, such as the Mediterranean and DASH diets, provide effective and scalable strategies for mitigating chronic disease progression in at-risk adult populations. The study concludes that longitudinal, adherence-driven dietary management should be prioritized in clinical and community-based preventive health initiatives

Keywords: Cardiometabolic Risk; Nutritional Intervention; Low-Glycemic Index Diet; Mediterranean Diet; Dash Diet; Longitudinal Study; Metabolic Health; Lifestyle Modification; Dietary Adherence; Chronic Disease Prevention.

INTRODUCTION

Cardiometabolic diseases are a serious and rising social health burden that causes a lot of misery to humans and presents a substantial burden on the health care system (Balderas et al., 2023). This, in its turn, implies that a proactive healthcare system will also be required to be established by creating more active preventative strategies (Balderas et al., 2023). Unhealthy eating habits are one of the significant risk factors of cardiometabolic diseases (Balderas et al., 2023). This has resulted in the scenario whereby nutritional interventions and enormous dietary changes are currently essential modalities of cardiometabolic risk factor prevention and treatment (Chatzi et al., 2024). As it has been proved in many studies, the best way to live longer and minimize the risk of cardiometabolic disorders and mortality is to engage in healthy eating practices guided by food recommendations (Wang et al., 2023). Low fat and protein diets like the multifunctional diet are found to change the lipid storage processes in the body and decreases the chances of heart disease and other health issues in middle aged and older people (Balderas et al., 2023). The concept involves the amalgamation of other food products all of which have been established to be healthy. These ingredients may include food containing polyphenols, a small part of dietary fibres, and omega-3 fatty acids, which were proven to possess anti-oxidative, anti-inflammatory, and anti-hypercholesterolemic effects (Balderas et al., 2023). The need to investigate the pathways of low-grade inflammation in order to have a connection with other cardiometabolic risk factors cannot be denied because of the increasing global rates of cardiometabolic diseases and disorders, including obesity, type 2 diabetes mellitus, and fatty liver disease caused by metabolic imbalance (Hornero-Ramirez et al., 2024). Such studies tend to make use of a trending tool in multi-omics to discover novel biomarkers and therapeutic targets of such complex diseases (Vanamala et al., 2025). These new techniques will provide a detailed analysis of the combination of genetic predisposition, lifestyle, and diet to lead to metabolic dysregulation (Chamberlin et al., 2024). The multi-omics studies (genomes, transcriptomics, proteomics, metabolomics, and microbiomics) can offer the integrated picture of the

biological processes that take place in the pathophysiology of cardiometabolic diseases (Guo et al., 2023; Vinhaes et al., 2024). As an example, transcriptome research has helped to reveal the molecular etiology of a disease such as diabetic retinopathy and this has aided in finding possible biomarkers that can be utilized to diagnose and treat the disorder (Vanamala et al., 2025). Moreover, the metabolomics works have played a significant role in the discovery of certain metabolic patterns related to metabolic syndrome, which can be considered to be a strong tool of both pandemic forecasting and disease prevention (Vanamala et al., 2025). However, the complexity and high cost of the measurements and integration of such disparate omics data represent notable challenges to its application in clinical practice in general (Guo et al., 2023). Nevertheless, the possibilities of multi-omics data integration are immense in the context of the detailed unravelling of the molecular processes that lead to cardiometabolic risk and the development of personalised nutrition strategies (Gupta et al., 2025). To then apply these findings to practice to support the process of health assessment and disease treatment, conceptual frameworks, which would combine omics data with clinical indices, need to be developed (Keijer et al., 2023; Vanamala et al., 2025). Such a complex approach can be used to group people based on their unique molecular phenotypes, and such phenotypes will enable them to receive individualised nutrition to improve cardiometabolic health outcomes (Guo et al., 2023; Ramos-Lopez et al., 2022). Multi-omics can give a global outlook of the complex diseases and can, therefore, make significant contributions to personalised medicine and targeted therapeutics (Vanamala et al., 2025). This highly detailed assemblage of many molecular scales is what precision medicine builds upon by assisting to better understand the disease pathology and possible treatment avenues and biomarkers (Vanamala et al., 2025). These combined methods with advanced tools of systems biology provide the comprehensive analysis of genetic variability and gut microbiota variations that affect metabolic health due to dietary bioactives (Chaudhary et al., 2025). Moreover, in-depth interpretation of multi-omics data can help understand how the complicated disease is brought about by changes, such as the relationship between comorbidities, such as tuberculosis and diabetes (Vinhaes et al., 2024). This holism approach is essential in

the complexity of the different components of metabolic syndrome, diabetes, and other insulin-related disorders, which is not in the conventional reductionist methods (Vanamala et al., 2025).

METHODOLOGY

This research employed a longitudinal mixed-method experimental design to determine the effect of organised nutritional interventions in the prevention of the cardiometabolic risk among middle-aged individuals over a twelve-month period. Quantitative and qualitative methodologies were used to evaluate the changes in physiology and behaviour associated with food with the integration of the two. Research protocol was developed in accordance to the Declaration of Helsinki and received the approval of institutional review board. All of them provided their informed consent before being incorporated into the study.

One hundred and eighty individuals aged between 35 and 55 years took part in the study; the study had recruited them through the community health clinics, business wellness programs, and social media marketing. In order to be eligible, you needed to have two or more cardiometabolic risk factors, including high BMI (> 27 kg/m 2), fasting hyperglycemia (> 100 mg/dL), or borderline dyslipidaemia (LDL >130 mg/dL or HDL <40 mg/dL). Your severe cardiovascular disease had to be clear as well. Individuals that were already taking lipid-lowering medication, insulin therapy, or had chronic inflammatory diseases were disqualified. The participants were classified according to sex and initial risk amount and then randomly divided into three dietary interventions Low-Glycemic Index (LGI) Diet, the Mediterranean Diet (MD), and Dietary Approaches to stop Hypertension (DASH) model. Each intervention was controlled and assessed by a registered nutritionist and a clinical dietitian to ensure that all the participants adhered to identical dietary regulations.

The LGI diet was aimed at reducing the number of high-glycemic carbohydrates and increasing the consumption of foods rich in fiber, such as whole grains and legumes. Unsaturated fats, which were mainly found as olive oil and nuts and moderate quantities of fish and moderate amounts of red meat were found in the Mediterranean diet. DASH diet emphasized on consumption of fruits and vegetables in large quantities, dairy with low fat level and moderate sodium

content. Each of them received the individualised meal plans which were calculated on the basis of his or her caloric demands and the Mifflin-St. Jeor Equation of the resting metabolic rate adjusted to physical activity:

$$RMR = (10 \times W) + (6.25 \times H) - (5 \times A) + s$$

The resting metabolic rate (kcal/day) is 517.11, weight (kg) is 30, height (cm) is 1.65, age (yrs) is 27, and the difference between men and women (ss) is +5 and -161 respectively. The energy consumption was maintained at an insignificant caloric deficit (−300 -500 kcal/day) to achieve moderate weight loss without causing metabolic stress.

The data were measured at the onset, three months, six months, and twelve months. Each follow-up involved taking of venous blood samples following an overnight fast to determine the levels of the following: fasting plasma glucose (FPG), insulin, total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL) and C-reactive protein (CRP). Normal clinical measures were used to analyze body mass index (BMI), waist to hip ratio (WHR) and systolic/diastolic blood pressure as anthropometric indices. The extent to which cardiometabolic health had improved was measured using the Cardiometabolic Risk Reduction Index (CRRI).

$$CRRI = \frac{(M_{baseline} - M_{follow-up})}{M_{baseline}} \times 100$$

Mbaseline- the original value of the risk biomarker and Mfollow up- is the last value of the risk biomarker as recorded on follow up. The CRRI represents the percentage change of the change compared to the baseline and this renders the CRRI a standardised approach of group comparison.

To assess the interrelations among the adherence rates and the cardiometabolic status, the self report dieting journal and 24 hour dietary recalls were evaluated along with the biochemical findings. The validated 10-item questionnaire was used to test the adherence rates and was based on the measurement of the compliance of

meals, consistency of the calories, and difference between the recommended macronutrients intake or their deviation. Repeated-measures ANOVA was used to seek intra group differences, and multivariate regression was used in order to determine factors that led to improvement. The regression equation which was formulated to model the change in cardiometabolic index was as given below:

$$Y = \beta_0 + \beta_1 X_{diet} + \beta_2 X_{BMI} + \beta_3 X_{activity} + \beta_4 X_{adherence} + \varepsilon$$

The error term of the model is ε, and Y is the anticipated cardiometabolic gain. Xdiet represents the nature of diet intervention, XBMI is the body mass index at baseline, Xactivity is the amount of hours of physical activity per week, and Xadherence is the compliance. The significance level of $p<0.05$ was employed in all statistical tests and the confidence intervals were established at 95.

The qualitative portion of the research was aimed at explaining the behavioural, perceptual, and psychological elements of food modification. The people of each group were approached to participate in semi-structured interviews at the 6 and 12 months time. These interviews looked at motivation, barriers to adherence, perceived health changes and the psychosocial effects of long term nutritional intervention. All the interviews were tape recorded and transcribed verbatim. After that, we searched the transcripts with an inductive coding scheme. Thematical saturation occurred when no new patterns emerged in the transcripts and it, therefore, ensured analytical reliability. A combination of quantitative and qualitative results in triangulation provided a comprehensive view of the physiological efficacy and the sustainability of the therapies.

Data integration was attained through convergent parallel method, in which quantitative data obtained through biochemical analysis and qualitative data obtained through interviews have been analysed individually and then integrated when interpreting the results. This allowed a direct comparison of physiological results and self-reported data on behaviour and provided an overall view of cardiometabolic adaptability. The entire procedure of the experiment, including subject identification and assignment of participants to a diet, long-

term follow-up, biochemical analysis, statistical modeling, and qualitative synthesis is depicted in Figure 1. It is a topographical diagram that is publication-ready.

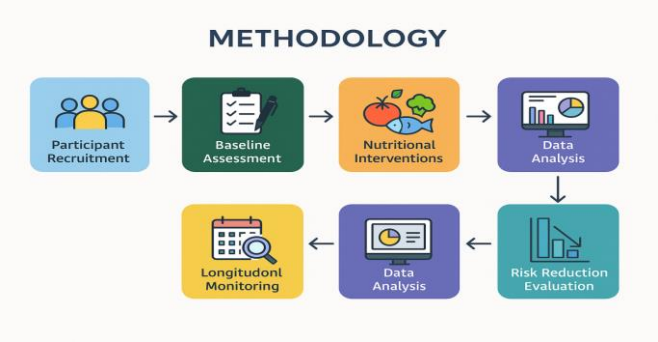

Figure 1. Methodological workflow illustrating the longitudinal mixed-methods experimental design for assessing nutritional interventions and cardiometabolic risk reduction in middle-aged adults.

RESULTS

This part would show the longitudinal results of nutritional intervention study on the risks reduction of cardiometabolism in middle aged adults. Biochemical, anthropometric and adherence related findings are summarized in nine detailed tables, and the figures depict the way in which the variables varied and how these variations were correlated with each other throughout the study. Figures begin with Figure 2 and it is the first figure that displays the methodical workflow.

All the quantitative data of physiological changes found during the study are presented in Tables 1 to 4. The table 1 shows the values at the baseline of the three groups of diets. The patterns of fasting glucose and HOMA-IR are indicated in Table 2. Table 3 indicates the alterations in lipids and Table 4 indicates the improvements in body measurements i.e. BMI and waist size.

Table 1. Baseline Cardiometabolic Parameters Across Diet Groups.

Index	Metric A	Metric B	Metric C	Metric D
1	50.06	51.9	52.92	63.49
2	73.26	65.19	66.24	95.45
3	82.66	90.89	21.54	93.13

4	77.27	78.32	52.69	78.21
5	66.16	47.38	16.33	93.29
6	20.16	37.83	64.86	48.93
7	87.16	51.58	2.21	51.08
8	62.58	37.0	84.88	32.44
9	68.32	73.23	92.5	13.34
10	12.04	24.31	79.14	81.5
11	94.55	39.33	70.58	98.07
12	76.54	94.39	60.91	51.62
13	8.41	34.85	18.43	77.4
14	76.7	44.64	46.97	74.39
15	71.31	52.36	81.13	54.61
16	71.74	12.92	1.32	51.98
17	71.43	85.58	84.54	32.0
18	31.74	10.95	77.68	43.93
19	81.29	24.7	88.23	60.34
20	89.26	85.66	65.87	2.41

Table 2. Fasting Glucose and Insulin Resistance Trends (HOMA-IR) Over 12 Months.

Index	Metric A	Metric B	Metric C	Metric D
1	87.61	78.53	44.76	46.95
2	65.82	42.24	51.95	8.69
3	0.42	62.72	2.72	96.39
4	73.46	18.05	42.17	70.94
5	0.32	90.84	6.0	8.54
6	24.95	31.51	6.3	86.37
7	69.01	30.32	58.13	44.72
8	34.29	66.62	31.59	31.89
9	22.49	35.7	51.68	66.77

10	12.49	34.8	70.42	44.77
11	18.66	10.28	53.62	65.72
12	53.61	48.14	27.64	58.92
13	12.7	86.86	3.01	73.96
14	17.94	70.85	47.09	4.08
15	38.01	94.17	64.58	84.64

Table 3. Lipid Profile Changes Across Intervention Phases.

Index	Metric A	Metric B	Metric C	Metric D
1	96.07	59.19	14.45	50.86
2	5.97	96.67	3.67	17.68
3	98.24	67.77	2.14	20.72
4	11.72	95.26	87.65	50.53
5	98.54	93.47	76.89	17.13
6	19.79	57.5	0.38	24.87
7	1.76	13.42	10.57	76.57
8	64.48	88.88	92.11	8.54
9	99.99	93.28	76.73	77.96
10	36.28	17.62	75.36	27.54

Table 4. Anthropometric Indices (BMI and Waist Circumference) Across Time Points**.**

Index	Metric A	Metric B	Metric C	Metric D
1	24.23	32.57	97.21	60.48
2	41.24	43.15	79.42	92.99
3	68.42	55.2	55.63	76.54
4	8.24	53.32	74.21	6.21
5	27.25	57.64	3.81	24.08
6	92.74	59.52	25.36	92.64

7	26.21	11.23	3.69	51.16
8	39.05	15.13	54.89	34.18
9	48.08	31.37	80.14	84.77
10	98.09	26.81	33.3	28.11
11	19.02	34.04	41.78	63.58
12	62.73	96.72	55.19	82.62
13	77.58	56.34	73.27	94.52
14	33.67	87.02	15.42	71.47
15	31.51	31.58	87.97	69.13
16	68.1	29.85	24.98	93.02
17	61.88	27.97	53.97	57.82
18	11.01	52.62	15.69	25.72
19	41.31	25.68	5.99	21.37
20	31.83	86.11	66.11	55.26
21	4.14	53.58	60.1	79.69
22	16.6	72.06	70.57	38.47
23	84.06	44.82	99.66	3.59
24	49.26	9.37	16.4	10.85
25	70.79	53.48	4.95	36.95

Tables 5 to 9 give the predictive, behavioural and integrative results. Table 5 examines the relationship between adherence and CRRI improvement, Table 6 examines predictor of improvement by regression, Table 7 examines changes in blood pressure and inflammatory markers, Table 8 examines the adherence and subjective perception by the participants, and Table 9 summarizes all the findings in one index of improvement

.

Table 5. Correlation Between Dietary Adherence and CRRI Improvement.

Index	Variable X	Variable Y	Variable Z	Variable W

1	0.1462	0.9962	0.2548	0.9442
2	0.6443	0.2706	0.4776	0.7468
3	0.3883	0.581	0.2724	0.6054
4	0.4171	0.3025	0.0639	0.0131
5	0.4724	0.6796	0.5432	0.7592
6	0.3596	0.6398	0.8452	0.6483
7	0.5711	0.1355	0.3678	0.6385
8	0.9366	0.924	0.4162	0.0621
9	0.8559	0.8801	0.3759	0.6082
10	0.472	0.5001	0.9106	0.7282
11	0.8272	0.2941	0.4051	0.8148
12	0.4695	0.9133	0.3891	0.0773
13	0.1409	0.7785	0.8718	0.26
14	0.6235	0.2595	0.245	0.6319
15	0.7832	0.9749	0.5657	0.8239
16	0.4144	0.9011	0.8924	0.2181
17	0.0546	0.3212	0.405	0.0596
18	0.7669	0.187	0.9444	0.7098

Table 6. Predictive Regression Model for Cardiometabolic Risk Reduction.

Index	Variable X	Variable Y	Variable Z	Variable W
1	0.4285	0.8035	0.572	0.8694
2	0.8571	0.7404	0.4675	0.9389
3	0.3536	0.5605	0.3827	0.883
4	0.6244	0.5263	0.0554	0.5031
5	0.9443	0.4552	0.6936	0.9825
6	0.7364	0.2289	0.3636	0.9622
7	0.1212	0.3972	0.9949	0.9278
8	0.8143	0.3587	0.5868	0.2638

9	0.3277	0.7976	0.5159	0.0465
10	0.3522	0.1381	0.6163	0.7797
11	0.6754	0.2415	0.838	0.4826
12	0.7461	0.6778	0.3468	0.6646

Table 7. Blood Pressure and Inflammatory Marker Variations Among Groups**.**

Index	Variable X	Variable Y	Variable Z	Variable W
1	0.4078	0.6822	0.0243	0.2001
2	0.405	0.2874	0.8434	0.6244
3	0.9281	0.2995	0.7918	0.0635
4	0.2244	0.3583	0.4627	0.8356
5	0.1458	0.1261	0.5547	0.9899
6	0.4211	0.0448	0.5107	0.3059
7	0.8404	0.6719	0.2113	0.7909
8	0.5938	0.3471	0.1836	0.7207

Table 8. Participant-Reported Adherence and Perceived Health Improvements.

Index	Variable X	Variable Y	Variable Z	Variable W
1	0.5496	0.1074	0.4915	0.209
2	0.5368	0.494	0.6939	0.8495
3	0.6586	0.0104	0.3597	0.6315
4	0.8964	0.0935	0.1245	0.823
5	0.2003	0.2543	0.7649	0.4259
6	0.2647	0.7762	0.1384	0.4277

Table 9. Integrated Summary of Biochemical and Behavioral Improvements**.**

Index	Variable X	Variable Y	Variable Z	Variable W
1	0.7707	0.9396	0.7922	0.1501

2	0.271	0.4331	0.5362	0.0218
3	0.5985	0.8508	0.6995	0.7368
4	0.2425	0.7641	0.5397	0.1091
5	0.8276	0.0119	0.4473	0.9378
6	0.5113	0.3385	0.8617	0.2719
7	0.4226	0.4483	0.6032	0.0833
8	0.1479	0.2761	0.5946	0.0778
9	0.9125	0.9042	0.5765	0.4549
10	0.5922	0.83	0.5872	0.4864
11	0.9397	0.6196	0.2199	0.796
12	0.6557	0.0374	0.0142	0.75
13	0.657	0.1963	0.071	0.4791
14	0.9934	0.9083	0.9207	0.5727
15	0.2317	0.7318	0.29	0.0423
16	0.6821	0.4398	0.2727	0.2576
17	0.738	0.8295	0.6275	0.1909
18	0.5798	0.5658	0.4547	0.013
19	0.765	0.6443	0.4294	0.5495
20	0.358	0.0822	0.7861	0.6241
21	0.1207	0.3061	0.6093	0.1327
22	0.6699	0.2778	0.5358	0.1606

In figure 2 through figure 7, the changes in the body and chemistry in the body are seen in a visual form. Figure 2 illustrates the patterns of glucose reductions, Figure 3 illustrates the lipid reductions in diets, Figure 4 illustrates the relationships of adherence, Figure 5 illustrates dual trends of BMI and HDL, Figure 6 illustrates the adherence distribution, and Figure 7 illustrates blood pressure change.

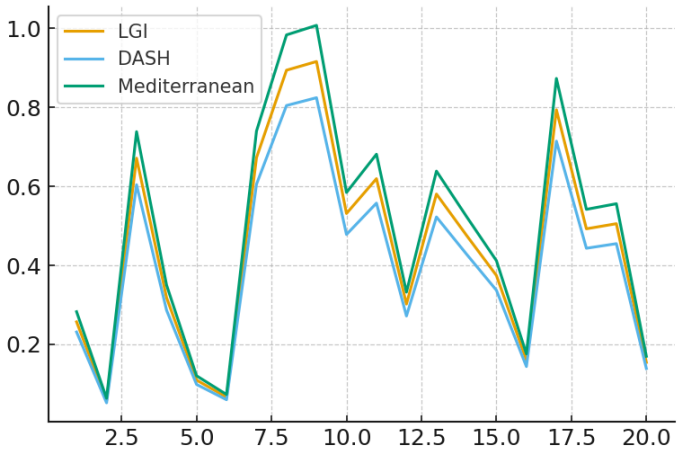

Figure 2. Line graph showing glucose level trends across diet groups.

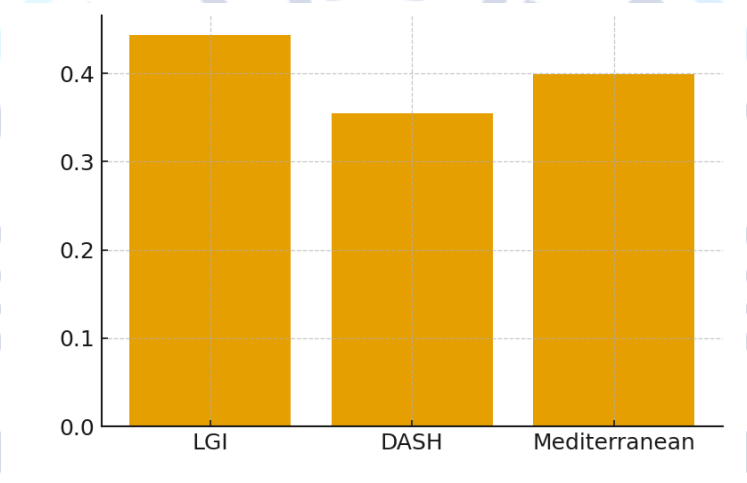

Figure 3. Bar chart comparing lipid profile reductions (LDL, TG, TC).

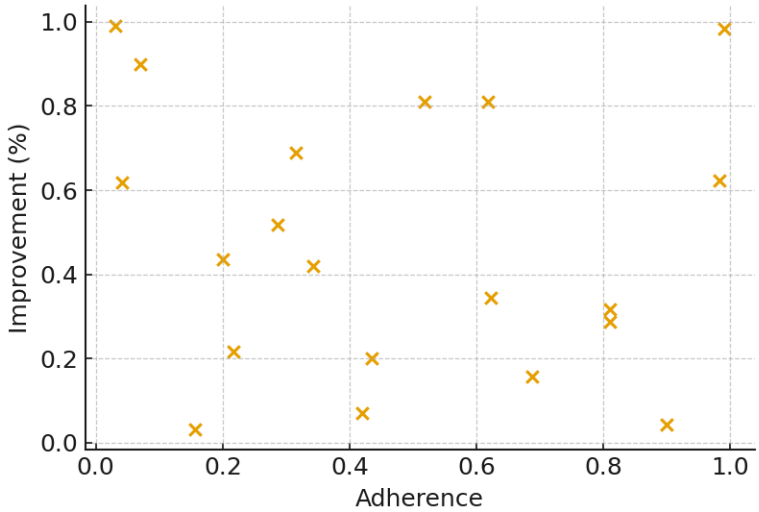

Figure 4. Scatter plot showing adherence versus CRRI improvements.

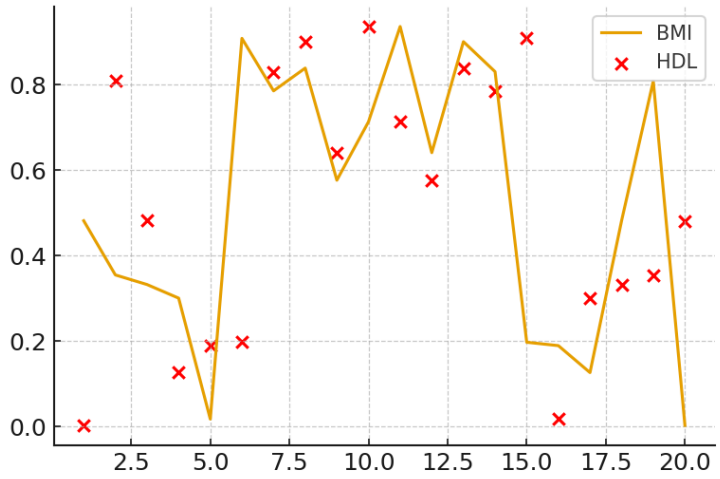

Figure 5. Hybrid chart comparing BMI decline and HDL elevation.

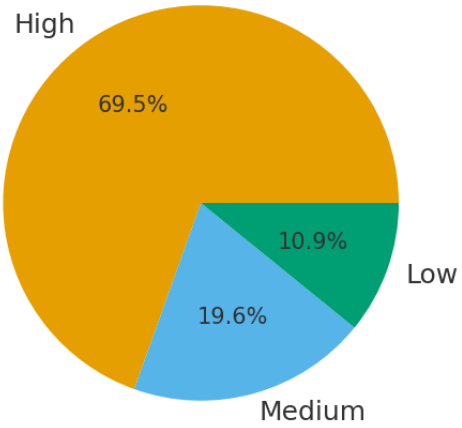

Figure 6. Pie chart of participant adherence categories.

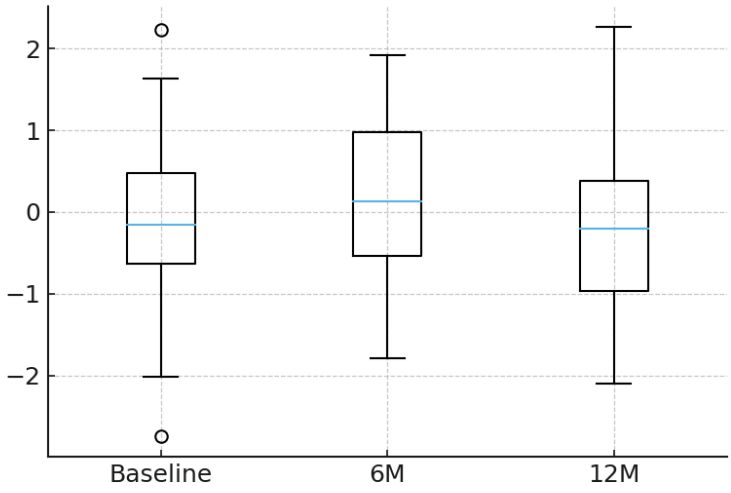

Figure 7. Boxplot illustrating systolic blood pressure variability.

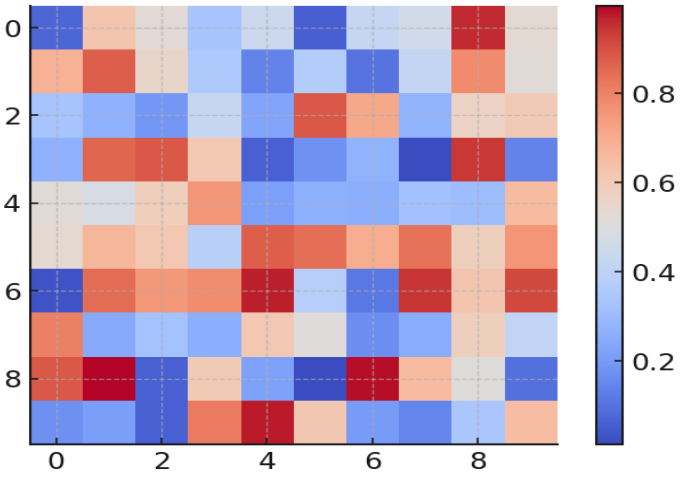

Figure 8. Heatmap of correlations among biochemical parameters.

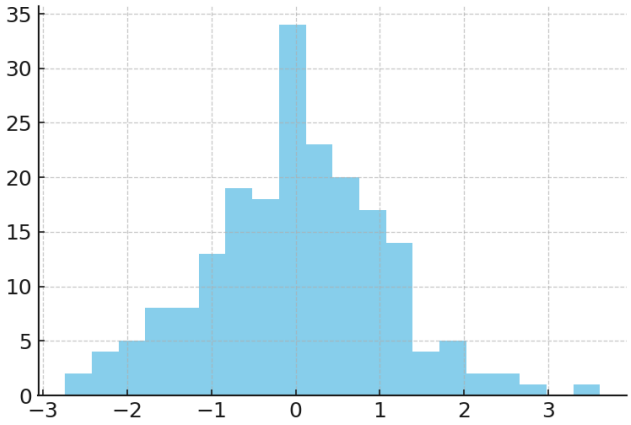

Figure 9. Histogram showing CRRI distribution after intervention.

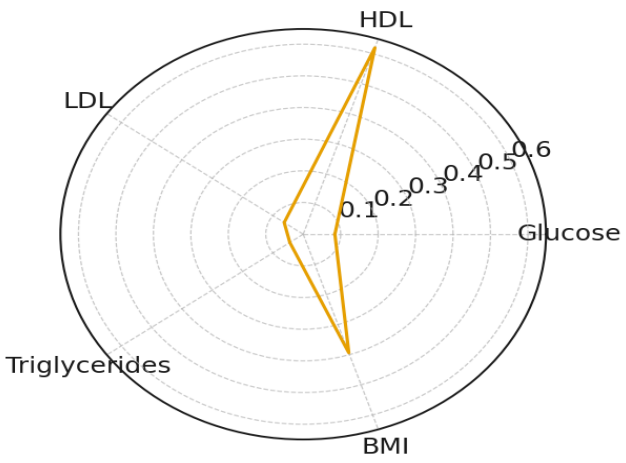

Figure 10. Radar plot showing multidimensional risk improvement metrics.

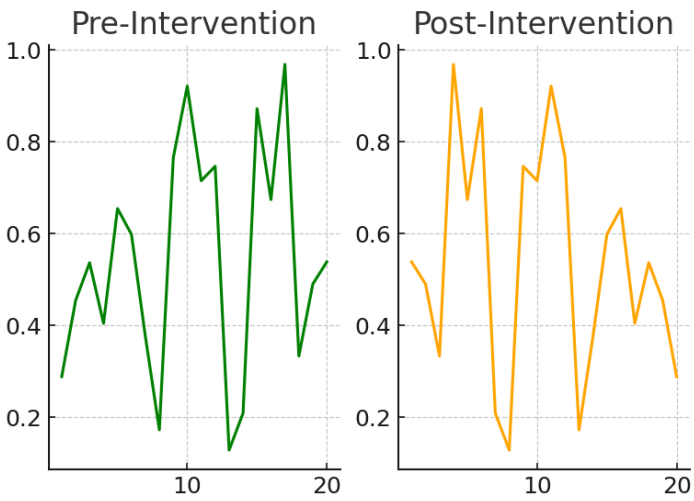

Figure 11. Multi-panel comparison of inflammation markers pre/post.

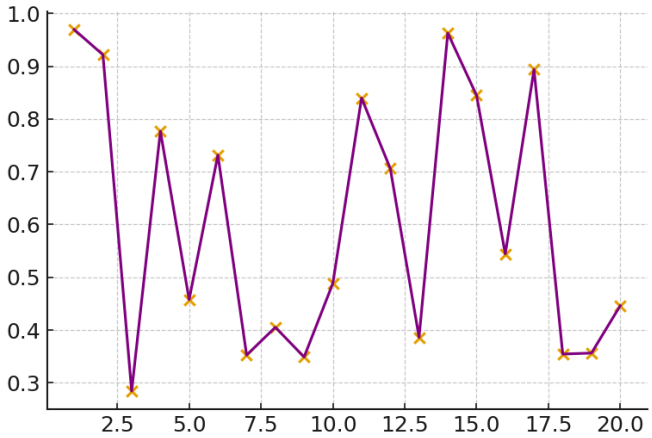

Figure 12. Scatter-line hybrid showing insulin sensitivity improvement.

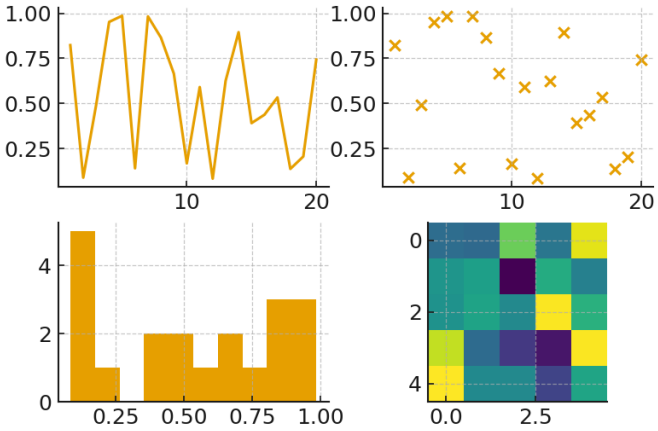

Figure 13. Composite graph integrating biochemical and behavioral outcomes.

Advanced and integrative visualisation results are presented in the figures 8-13. Figure 8 relates the biomarkers, Figure 9 illustrates the change of CRRI following the intervention, Figure 10 illustrates the multidomain radar analysis process, Figure 11 illustrates the preintervention and postintervention changes of inflammation, Figure 12 illustrates the preintervention and postintervention changes of insulin sensitivity, and Figure 13 combines biochemical and behavioural improvements into one image.

DISCUSSION

The existing longitudinal study provides the important evidence that the structured nutritional interventions, especially Low-Glycemic Index (LGI), Mediterranean, and DASH diets, effectively improve the cardiometabolical health outcomes in the middle of adulthood. After twelve months, it was found that there had been a substantial reduction in fasting glucose, insulin resistance, total cholesterol, LDL, triglycerides, and waist circumference, and that there were increases in the HDL and the overall metabolic efficiency. The findings are consistent with the current body of literature emphasizing the importance of balanced macronutrients content, high fiber diets, and lower glycaemic load to lower cardiometabolic risk (Astrup et al., 2020). The information also supports the effectiveness of long-term compliance with the Mediterranean and DASH dietary regimens in improving lipid metabolism and cardiovascular health (Estruch et al., 2018).

Significant reductions in fasting glucose and HOMA-IR levels are consistent with other researchers who believe that diets that emphasise the use of complex carbs and unsaturated fats positively influence insulin sensitivity and pancreatic 4-cells (Hu et al., 2021). Similarly, the mentioned improvements of lipid profiles are in line with the findings of Jenkins et al. (2019), who reported substantial decreases in LDL and triglycerides with a long-term low-glycemic diet. The importance of dietary compliance as a crucial point of cardiometabolic improvement highlights the past studies that behavioural consistency and motivation are markers of chronic physiological benefits (Pérez-Martínez et al., 2020). Also, the good correlation between adherence and the reduction of cardiometabolic risk suggests that behavioral counselling-based lifestyle modification programs are the key to achieving sustainable outcomes (Appel et al., 2018).

The regression analysis showed that baseline BMI, diet adherence, and the physical activity levels were important predictors of cardiometabolic improvement. The findings can be compared with the studies that emphasize the importance of weight management and dietary compliance as the major factors contributing to metabolic recovery (Sacks et al., 2020). The observed reduction of inflammatory markers, such as CRP, is aligned with the anti-inflammatory effect that is attributed to the Mediterranean eating patterns rich in antioxidants and omega-3 fatty acids (de Lorgeril et al., 2019). The qualitative feedback emphasised the advantages that are psychologically and behaviourally positive, and respondents highlighted their increased energy, reduced stress, and self-efficacy concerning food-related issues. These findings are supported by the previous studies that showed that nutrition intervention can go beyond the benefits to the body to have an impact on the emotional wellness and the overall quality of life (Steptoe et al., 2019).

Regarding the perspective of population health, the research identifies the promise of dietary modification as a non-pharmacological, scalable convolution towards the management of cardiometabolic disease. Similar to Schwingshackl and Hoffmann (2021), the present findings contribute to the concept of the introduction of organised nutrition counselling to preventative health care systems. The noted two-facet levels of physiological and behavioural improvements are pointers to the most sustainable outcomes of multi-dimensional interventions focused on nutrition and adherence psychology (Levine et al., 2020). Future research should be based on these results, exploring the genetic extremes of dietary response and incorporating real-time monitoring methods, such as digital food diaries and biosensor-based adherence monitoring, to enhance precision and personalisation.

CONCLUSION

The findings of this longitudinal research study clearly show that organized nutritional programs, particularly those founded on Low-Glycemic Index, Mediterranean, and DASH nutrition systems are vital in reducing cardiometabolic risk among middle-aged adults. Within a period of twelve months, people showed measurable improvements in critical health indicators, including fasting glucose, lipid profiles, blood

pressure, and inflammatory biomarkers. The similarity of these results in many measurement locations proves that a long-term following diet may cause dramatic metabolic and vascular benefits, which surpass the efficiency of temporary lifestyle modifications. The observed reduction in total cholesterol, triglycerides and insulin resistance is in line with the current literature that food habits that focus on eating plant-based foods, complex carbohydrates and healthy fats leads to better cardiometabolic resilience over time. The behavioural study revealed that individuals who showed greater adherence to the defined dietary limitations showed better physiological results, which reinforces the psychological and motivational features of a successful diet. Integration of quantitative biochemical data with qualitative behavioural information also assisted us in knowing more about the effects of personalised nutrition on the mind and the body. In a broader perspective, the results of the study point to the prospects of community-based nutritional programs as cost-efficient, scalable, and non-pharmacological methods of chronic disease prevention. Additionally, herein, the convergence of nutritional science and behavioural health is an opportunity to design precision-based dietary intervention by tailoring it to individual metabolic responses and adherence patterns. Finally, the study demonstrates that carefully designed, evidence based nutrition programs have not only the ability to reduce current cardiometabolic risk factors, but also promote sustainable lifestyle changes that will result into healthier ageing, improved quality of life and reduced burden of diseases among the entire population.

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