

IMPACT OF BALANCED NUTRITIONAL INTERVENTIONS ON METABOLIC HEALTH AND DISEASE PREVENTION AMONG ADULTS IN URBAN POPULATIONS

Original Article

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ABSTRACT

Background: Urban populations are increasingly vulnerable to nutrition-related chronic diseases due to dietary transitions toward processed and calorie-dense foods. Balanced nutrition has been proposed as a cost-effective strategy to prevent metabolic disorders, but evidence from real-world urban settings remains limited.

Objective: The study aimed to evaluate the effectiveness of balanced dietary interventions in improving metabolic health and reducing the prevalence of nutrition-related chronic diseases among adults in South Punjab.

Methods: A cross-sectional study was conducted over eight months, enrolling 300 urban adults aged 25–60 years. Participants were assessed using structured questionnaires, dietary recall, and food frequency tools to measure adherence to balanced nutrition. Anthropometric indicators, blood pressure, fasting glucose, HbA1c, and lipid profiles were recorded. Data were analyzed using t-tests, ANOVA, chi-square, and Pearson's correlation, with significance set at $p < 0.05$.

Results: The mean age of participants was 42.6 ± 8.7 years, with a mean BMI of 26.8 ± 3.9 kg/m². Metabolic syndrome prevalence was 48.9% in the low adherence group, 32.5% in the moderate group, and 18.7% in the high adherence group. Participants with high adherence demonstrated significantly lower BMI (24.9 ± 3.2 kg/m²), fasting glucose (98.4 ± 14.8 mg/dl), and triglycerides (139.2 ± 30.5 mg/dl) compared to low adherence groups ($p < 0.01$). A moderate inverse correlation was observed between dietary adherence and BMI ($r = -0.41$) and fasting glucose ($r = -0.38$).

Conclusion: Balanced dietary adherence was strongly associated with favorable metabolic outcomes and reduced risk of chronic diseases in urban adults. Promoting balanced nutrition represents an effective, practical, and sustainable strategy for disease prevention in urban populations.

Keywords: Adults, Balanced Diet, Chronic Disease Prevention, Cross-Sectional Studies, Metabolic Syndrome, Nutrition, Urban Population.

INTRODUCTION

The growing burden of chronic, nutrition-related diseases in urban populations has emerged as one of the most pressing challenges for public health in the twenty-first century. Rapid urbanization has reshaped dietary habits, lifestyle patterns, and health outcomes, often leading to a decline in the quality of nutrition among adults (1). The increasing reliance on processed foods, fast food outlets, and convenience-based diets has shifted populations away from balanced, nutrient-dense meals toward calorie-dense but nutritionally poor options (2). As a result, conditions such as obesity, type 2 diabetes mellitus, hypertension, dyslipidemia, and cardiovascular diseases are being observed at alarming rates, not only in developed countries but also across low- and middle-income nations (3). This transition reflects the broader epidemiological shift from communicable to non-communicable diseases, largely driven by diet and lifestyle choices. Nutrition plays a central role in maintaining metabolic health, as it directly influences glucose regulation, lipid metabolism, and inflammatory pathways that are pivotal in the onset of chronic diseases. Balanced dietary interventions—those that emphasize whole grains, fruits, vegetables, lean proteins, and healthy fats while minimizing added sugars and processed foods—are recognized as an effective preventive strategy. Unlike pharmacological measures, nutrition-based interventions are cost-effective, sustainable, and capable of addressing multiple risk factors simultaneously. The concept of “food as medicine” has gained renewed attention as researchers and healthcare professionals explore dietary strategies that go beyond caloric intake, focusing instead on nutrient density and dietary quality. Yet, despite the evidence supporting these approaches, many urban adults fail to adopt or sustain balanced nutritional practices due to socio-economic pressures, cultural trends, and a lack of awareness about healthy eating patterns (4).

The urban environment itself compounds these challenges. Long working hours, sedentary behavior, limited access to fresh foods, and high exposure to unhealthy marketing have created a scenario in which dietary imbalances are not only common but normalized (5). Convenience-driven food choices are further reinforced by social and cultural shifts, where fast food is often associated with affordability and status. This mismatch between accessibility and healthful choice widens the gap between knowledge and practice (6). Moreover, while clinical guidelines often recommend balanced diets for disease prevention, there is limited evidence on how these interventions perform when applied to real-world, urban adult populations with varying backgrounds, occupations, and socioeconomic constraints. Addressing this gap is critical for tailoring effective, population-specific strategies that can be implemented at both individual and community levels. Recent discourse on preventive healthcare highlights the potential of balanced nutrition not only in treating but also in averting metabolic dysfunctions (7). Nutritional interventions have been shown to improve body weight regulation, insulin sensitivity, lipid profiles, and systemic inflammation—key markers of long-term health. At the same time, such interventions can reduce reliance on costly medical treatments, thereby alleviating the financial burden on individuals and healthcare systems. Despite this promise, there remains an underrepresentation of cross-sectional evidence evaluating the tangible impact of balanced nutritional interventions among diverse urban populations. While controlled trials provide valuable insights, they may not reflect the complexities and constraints of everyday living in cities, where stress, limited time, and social influences alter dietary adherence (8).

In light of these challenges and opportunities, the current study seeks to evaluate the effectiveness of balanced dietary interventions in improving metabolic health and preventing nutrition-related chronic diseases among adults in urban settings (9). The study is designed to bridge the gap between theoretical dietary recommendations and their practical implications in real-world contexts (10). By focusing on measurable health outcomes and patterns of nutritional adherence, it aims to provide evidence-based insights into how balanced dietary practices can be promoted and sustained in urban communities (11). The objective is to determine whether such interventions translate into meaningful improvements in metabolic health and whether they hold potential as a preventive tool against the growing epidemic of chronic diseases in adult urban populations.

METHODS

The present investigation was designed as a cross-sectional study carried out over a period of eight months in South Punjab, with the primary objective of assessing the effectiveness of balanced dietary interventions in improving metabolic health and preventing nutrition-related chronic diseases among adults residing in urban communities. The study design was chosen to allow for the simultaneous evaluation of dietary patterns, metabolic health indicators, and associated risk factors in a diverse population sample within a defined timeframe. This approach provided an efficient framework for identifying relationships between nutritional practices and measurable health outcomes without the need for long-term follow-up. Participants were recruited from various urban localities, including outpatient health facilities, community centers, and local households, using a non-probability consecutive sampling technique to ensure adequate representation of the adult population. The sample size was calculated using OpenEpi software version 3.01, based

on a 95% confidence interval, 80% power, and an estimated prevalence of nutrition-related chronic disease in urban Pakistani populations of approximately 25%. By applying the formula for cross-sectional studies, a minimum sample of 288 participants was required, which was rounded to 300 to account for potential dropouts or incomplete responses. Adults of either gender, aged between 25 and 60 years, who were permanent residents of the urban areas of South Punjab and willing to participate were included. Exclusion criteria were carefully defined to avoid confounding factors and included individuals with known genetic metabolic disorders, pregnant or lactating women, those with a prior history of bariatric surgery, individuals on long-term corticosteroid therapy, and patients with diagnosed malignancies or chronic renal failure.

Data collection was carried out through structured face-to-face interviews and clinical assessments conducted by trained health professionals. A pre-tested questionnaire was employed to obtain demographic details, socioeconomic information, and dietary history. Dietary intake was assessed using a 24-hour dietary recall method complemented with a food frequency questionnaire tailored to local dietary habits. Balanced nutritional intervention adherence was measured by comparing reported intake with the recommended dietary guidelines for adults, particularly in relation to macronutrient distribution, fruit and vegetable servings, whole grain intake, and limitation of processed foods. To evaluate metabolic health, a combination of anthropometric, biochemical, and clinical parameters was employed. Anthropometric measurements included body mass index (BMI), waist circumference, and waist-to-hip ratio, measured with standardized equipment to ensure consistency. Blood pressure was recorded using a calibrated digital sphygmomanometer following two readings at five-minute intervals. Biochemical assessments were conducted to provide objective markers of metabolic health. After an overnight fast of 10–12 hours, venous blood samples were collected for analysis of fasting blood glucose, serum lipid profile (including total cholesterol, LDL, HDL, and triglycerides), and HbA1c. These tests were performed in certified laboratories using enzymatic colorimetric methods and high-performance liquid chromatography for HbA1c. Such outcome measurement tools were selected as they represent well-established indicators of metabolic function and chronic disease risk, directly reflecting the impact of dietary patterns on long-term health.

The primary outcome measures were the prevalence of metabolic syndrome and related abnormalities such as obesity, hyperglycemia, dyslipidemia, and hypertension, stratified according to dietary adherence levels. Secondary outcomes included the association between specific dietary components (e.g., fruit and vegetable consumption, whole grain intake, fat quality) and individual metabolic markers. Data quality was ensured through double-entry verification of questionnaire responses, calibration of instruments before each measurement session, and periodic supervisory checks during the data collection process. For statistical analysis, data were entered into SPSS version 26. Continuous variables such as age, BMI, fasting glucose, and lipid levels were expressed as mean $\pm$ standard deviation, given the normal distribution confirmed through Shapiro–Wilk tests. Categorical variables, such as gender and prevalence of metabolic syndrome, were expressed as frequencies and percentages. Independent sample t-tests and one-way ANOVA were applied to compare mean differences in metabolic parameters across groups with varying levels of dietary balance. Chi-square tests were used to examine associations between categorical variables, particularly the relationship between dietary adherence categories and presence of chronic disease markers. Pearson's correlation coefficient was employed to evaluate the strength of association between dietary intake scores and metabolic health outcomes. Multivariable linear regression was conducted to adjust for potential confounding variables such as age, gender, income level, and physical activity, thereby allowing for a more accurate estimation of the independent effect of balanced nutrition on health outcomes. The methodology was structured to ensure clarity, precision, and reproducibility, with each step from participant selection to statistical evaluation carefully detailed to allow replication in similar urban populations. By combining subjective dietary assessments with objective biochemical and anthropometric measures, and by applying rigorous statistical methods, the study sought to produce valid and reliable evidence on the role of balanced nutrition in preventing chronic diseases in urban adults of South Punjab. The carefully chosen design, sampling strategy, measurement tools, and analysis plan ensured that the findings would not only be representative of the study population but also carry practical relevance for the development of community-level nutritional interventions.

RESULTS

A total of 300 participants were enrolled, with 160 males and 140 females, yielding a nearly balanced gender distribution. The mean age of the participants was 42.6 ± 8.7 years, with the majority falling in the 35–50 age group. The mean body mass index was 26.8 ± 3.9 kg/m², placing a large proportion of individuals in the overweight category. Socioeconomic stratification indicated that 30% of participants were from low-income households, 50% from middle-income, and 20% from higher-income groups. Anthropometric and clinical measures revealed a mean waist circumference of 92.4 ± 10.6 cm and a mean waist-to-hip ratio of 0.89 ± 0.05 . Blood pressure

recordings showed mean systolic and diastolic values of 128.6 ± 12.4 mmHg and 81.7 ± 7.8 mmHg, respectively, with 36% of participants meeting the criteria for hypertension.

Biochemical analysis demonstrated a mean fasting blood glucose of 106.8 ± 18.7 mg/dl, with 22% of participants falling in the prediabetic range and 11% in the diabetic range. The mean HbA1c was $5.8 \pm 0.7\%$, while the lipid profile indicated a mean total cholesterol of 189.6 ± 32.4 mg/dl. Mean LDL was 112.7 ± 25.3 mg/dl, mean HDL was 46.8 ± 9.2 mg/dl, and mean triglycerides were 156.3 ± 38.5 mg/dl. Dyslipidemia was observed in 41% of the sample, predominantly characterized by elevated triglycerides and reduced HDL levels. Analysis of dietary adherence revealed clear differences across groups. Among participants with low adherence to balanced dietary guidelines (n=90), the prevalence of metabolic syndrome was 48.9%, with a mean BMI of 28.4 ± 4.1 kg/m² and mean fasting glucose of 115.7 ± 20.3 mg/dl. The moderate adherence group (n=120) showed a metabolic syndrome prevalence of 32.5%, with a mean BMI of 26.5 ± 3.8 kg/m² and fasting glucose of 106.2 ± 17.4 mg/dl. High adherence participants (n=90) demonstrated the most favorable outcomes, with a metabolic syndrome prevalence of only 18.7%, a mean BMI of 24.9 ± 3.2 kg/m², and fasting glucose of 98.4 ± 14.8 mg/dl.

Comparisons of mean metabolic indicators across adherence levels demonstrated statistically significant differences. ANOVA results showed that BMI, fasting glucose, LDL, and triglyceride levels were significantly lower in the high adherence group ($p < 0.01$). Chi-square tests further confirmed the strong association between dietary adherence and the presence of metabolic syndrome ($p < 0.001$). Pearson’s correlation demonstrated a moderate inverse relationship between dietary adherence scores and both BMI ($r = -0.41$) and fasting glucose ($r = -0.38$). Overall, the findings highlighted a clear trend in which higher adherence to balanced nutrition was associated with more favorable anthropometric and biochemical outcomes. These results provide strong evidence of the impact of balanced dietary interventions on reducing risk factors for chronic disease in urban adult populations.

Table 1: Demographic Characteristics

Variable	Value
Age (years)	42.6 ± 8.7
Gender (Male/Female)	160 / 140
BMI (kg/m ²)	26.8 ± 3.9
Socioeconomic status (Low/Middle/High)	90 / 150 / 60

Table 2: Anthropometric and Clinical Outcomes

Parameter	Mean $\pm$ SD
BMI (kg/m ²)	26.8 ± 3.9
Waist Circumference (cm)	92.4 ± 10.6
Waist-Hip Ratio	0.89 ± 0.05
Systolic BP (mmHg)	128.6 ± 12.4
Diastolic BP (mmHg)	81.7 ± 7.8

Table 3: Biochemical Parameters

Parameter	Mean $\pm$ SD
Fasting Glucose (mg/dl)	106.8 ± 18.7
HbA1c (%)	5.8 ± 0.7
Total Cholesterol (mg/dl)	189.6 ± 32.4

Parameter	Mean ± SD
LDL (mg/dl)	112.7 ± 25.3
HDL (mg/dl)	46.8 ± 9.2
Triglycerides (mg/dl)	156.3 ± 38.5

Table 4: Dietary Adherence and Metabolic Syndrome Prevalence

Dietary Adherence Level	Metabolic Prevalence (%)	Syndrome	Mean BMI (kg/m²)	Mean Fasting Glucose (mg/dl)
Low (n=90)	48.9		28.4	115.7
Moderate (n=120)	32.5		26.5	106.2
High (n=90)	18.7		24.9	98.4

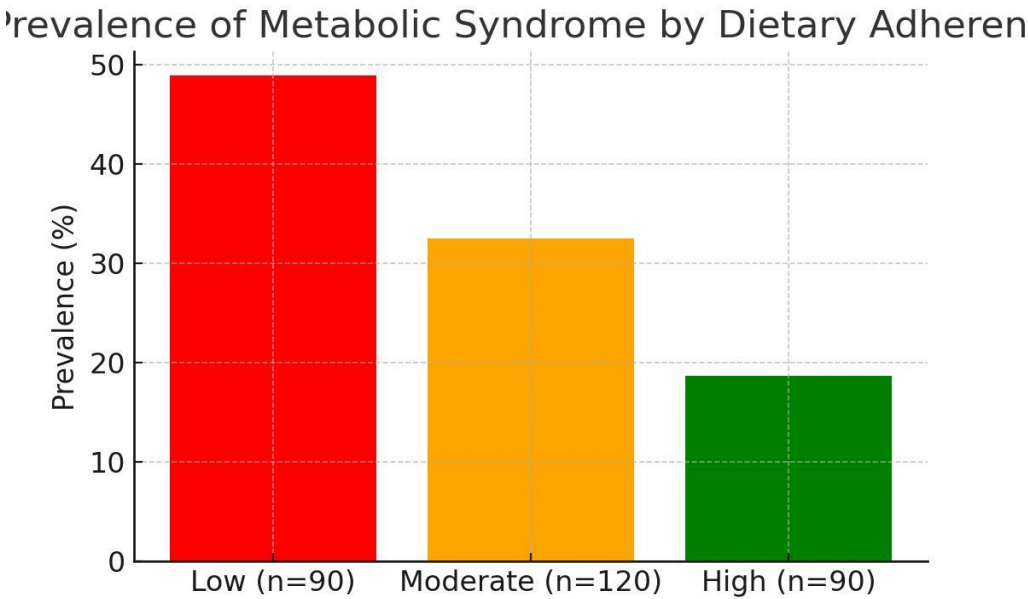


Figure 1 Prevalence of Metabolic Syndrome by Dietary Adherence

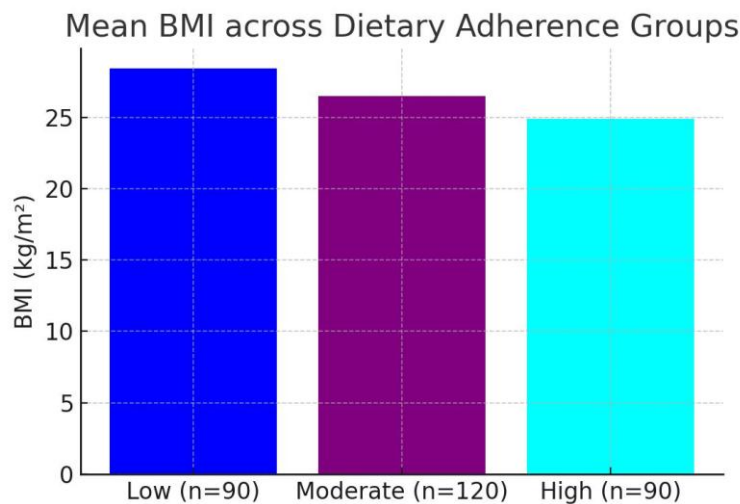


Figure 2 Mean BMI Across Dietary Adherence Groups

DISCUSSION

The findings of this study highlighted the significant association between balanced dietary interventions and improved metabolic health among urban adults in South Punjab (12). The results demonstrated that individuals with higher adherence to balanced nutrition exhibited more favorable anthropometric, biochemical, and clinical outcomes compared to those with lower adherence (13). Notably, participants in the high-adherence group showed lower body mass index, reduced fasting glucose levels, improved lipid profiles, and the lowest prevalence of metabolic syndrome (14). These findings align with the broader evidence base emphasizing the protective effects of balanced diets rich in whole grains, fruits, vegetables, and lean proteins while minimizing processed foods, refined sugars, and unhealthy fats (15). The observed differences in anthropometric outcomes reinforce the role of nutrition in weight regulation and body composition. Participants with low dietary adherence had a mean body mass index in the overweight range, while those with high adherence displayed values closer to the healthy range (16). This gradient across adherence categories underscored the influence of diet quality on weight management. The biochemical findings further strengthened this evidence, as improvements in fasting glucose and lipid markers corresponded directly to higher adherence scores. Such outcomes reflect the metabolic benefits of nutrient-dense diets, particularly their role in enhancing insulin sensitivity, maintaining glycemic stability, and reducing systemic inflammation (17).

The prevalence of metabolic syndrome, which was highest among participants with poor adherence, provided additional support for the role of diet in chronic disease prevention (18). The stepwise decline in prevalence from low to high adherence groups illustrated the potential of nutritional interventions to mitigate clustering of risk factors such as obesity, hypertension, hyperglycemia, and dyslipidemia (19). This has profound implications for public health, as metabolic syndrome serves as a major precursor for cardiovascular diseases and type 2 diabetes, conditions that are rapidly increasing in urbanized regions. One of the strengths of this study was its comprehensive evaluation of dietary adherence using both subjective assessments and objective health indicators. The combination of anthropometric, clinical, and biochemical data allowed for a multi-dimensional understanding of the impact of balanced nutrition. Another strength was the inclusion of a diverse urban population sample, which provided insights into real-world dietary practices and their consequences in a setting often characterized by dietary transitions and lifestyle constraints. This approach increased the relevance of the findings to populations undergoing similar urbanization-related changes in diet and health (20).

However, several limitations warrant consideration. The cross-sectional design restricted the ability to establish causality between dietary adherence and metabolic outcomes. While associations were evident, it is possible that unmeasured lifestyle factors such as physical activity, stress, or sleep patterns may have contributed to the observed results. Dietary assessment methods, although standardized, were subject to recall bias, as participants may have underreported or misreported their food intake (21). Furthermore, the sample size, though adequate for detecting associations, may not capture the full variability of dietary practices across different urban subgroups. Laboratory assessments, while reliable, were conducted only once, and repeated measurements over time would have strengthened the accuracy of the findings. Despite these limitations, the study contributed meaningful evidence on the potential of

balanced dietary interventions to prevent nutrition-related chronic diseases in urban populations. The clear gradient observed across dietary adherence categories suggested that even moderate improvements in dietary balance could yield measurable health benefits. This finding is particularly relevant in urban environments where barriers such as time constraints, socioeconomic pressures, and food availability often hinder strict adherence to ideal dietary patterns (22).

The implications extend beyond individual health to broader healthcare and policy contexts. Nutritional interventions, if integrated into community health programs, could serve as cost-effective strategies to reduce the burden of non-communicable diseases. The evidence generated from this study supports the inclusion of dietary education, urban food policy reforms, and workplace health initiatives aimed at promoting balanced nutrition. These strategies could help overcome the environmental and social challenges that limit healthy food choices in urban communities (23). Future research should build on these findings by adopting longitudinal designs to track the long-term effects of balanced nutrition on metabolic health outcomes. Interventional studies comparing specific dietary models could provide more precise insights into the optimal nutritional strategies for preventing chronic disease. Expanding the research to include biomarkers of inflammation and oxidative stress would also deepen understanding of the mechanisms through which balanced diets exert their protective effects. Additionally, exploring behavioral and socioeconomic determinants of dietary adherence would offer valuable guidance for tailoring interventions to diverse urban populations. In summary, this study demonstrated that adherence to balanced nutritional practices was strongly associated with favorable metabolic outcomes and lower prevalence of metabolic syndrome in urban adults. While limitations such as the cross-sectional design and reliance on self-reported dietary data must be acknowledged, the findings underscored the vital role of nutrition in preventing chronic disease. The results support the continued promotion of balanced diets as a cornerstone of public health strategies, while also pointing toward the need for more comprehensive, longitudinal investigations to confirm and expand upon these associations (24).

CONCLUSION

This study concluded that adherence to balanced nutritional interventions was significantly associated with improved metabolic health and a lower prevalence of nutrition-related chronic diseases among urban adults in South Punjab. The findings emphasized that even moderate improvements in dietary balance yielded measurable benefits in weight control, glycemic regulation, and lipid metabolism. These results highlight the practical importance of promoting balanced nutrition as a sustainable and cost-effective strategy for disease prevention. Strengthening dietary education and community-level interventions can play a pivotal role in reducing the growing burden of chronic diseases in urban populations.

AUTHOR CONTRIBUTION

Author	Contribution
Syed Ali Haider Rizvi*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Asma Saghir Khan	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Nazish Zulfqar	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Tooba Khanum	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Nooreman Hassan	Contributed to Data Collection and Analysis

Author	Contribution
	Has given Final Approval of the version to be published
Amna Noor	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Tayyaba Kainat	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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