

Dietary Habits, Nutritional Status, and Socioeconomic Factors Among University Students in Punjab, Pakistan: A Multicity Nutritional and Social Survey

Muhammad Riaz*¹, Muhammad Abdullah Butt*², Qaisar Sohail³, Talha Riaz⁴, Ambreen Saleem⁵

¹ Visiting lecturer, Department of Sociology Government College University, Faisalabad.

*Corresponding Author (mriaz6785@gmail.com)

² Department of Food Science, Government College University, Faisalabad

*Corresponding Author: (muhammadabdullahbuttfst@gmail.com)

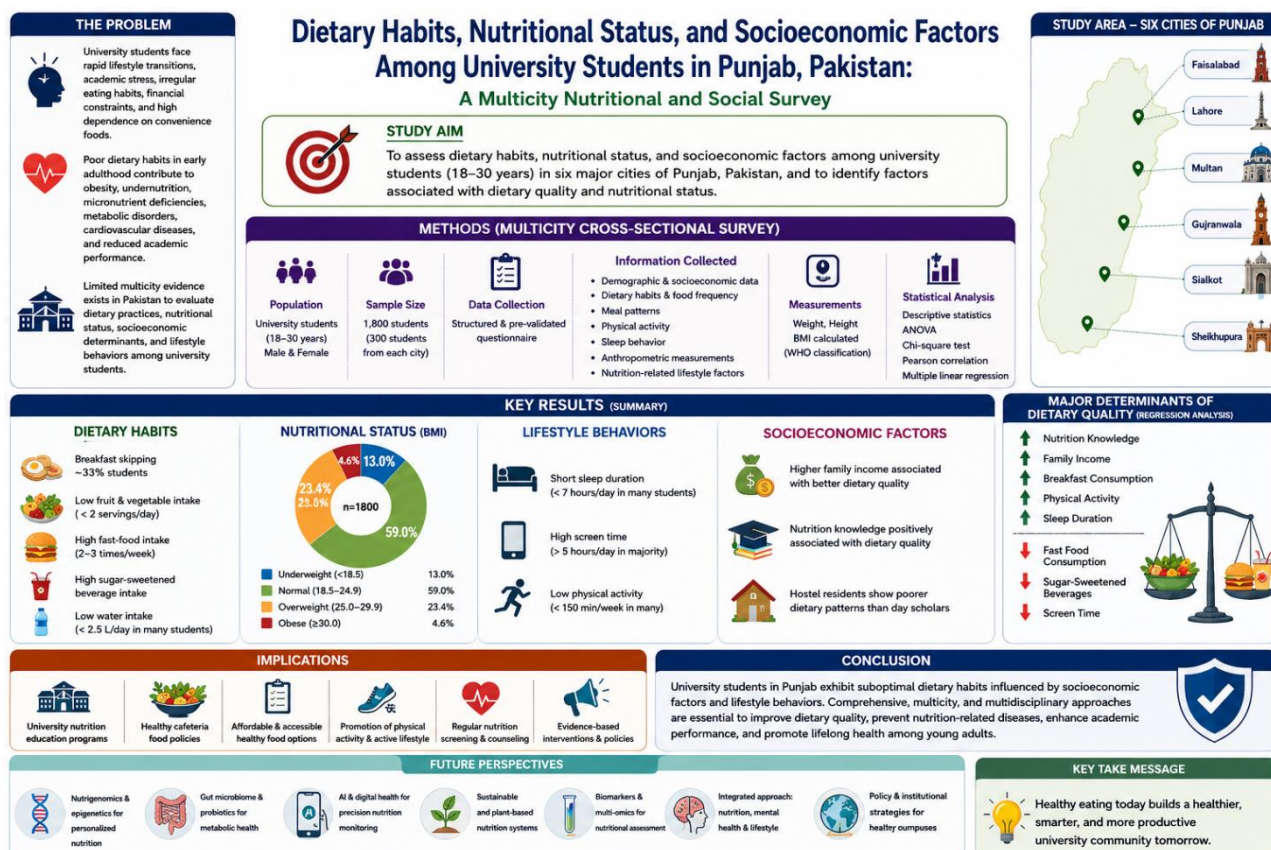
³ Data Analyst PKNC, UAF. (qaisr.gcuf@gmail.com)

⁴ National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan. (talhariaz2844@gmail.com)

⁵ Department of Food Science, Government College University, Faisalabad (amberose786@gmail.com)

DOI: <https://doi.org/10.70670/sra.v4i2.2370>

Graphical Abstract



Abstract

University students represent a nutritionally vulnerable population due to rapid lifestyle transitions, academic stress, irregular eating schedules, financial constraints, and increasing dependence on convenience foods. Poor dietary habits established during early adulthood contribute to obesity, undernutrition, micronutrient deficiencies, metabolic disorders, cardiovascular diseases, and reduced academic performance later in life. In Pakistan, limited multicity investigations have simultaneously evaluated dietary practices, nutritional status, socioeconomic determinants, and lifestyle behaviors among university students across major urban centers of Punjab. Therefore, the present study aimed to assess dietary habits, nutritional status, and socioeconomic factors among university students residing in six major cities of Punjab, Pakistan. A multicity cross-sectional survey was conducted among university students aged 18–30 years enrolled in public and private universities located in Faisalabad, Lahore, Multan, Gujranwala, Sialkot, and Sheikhpura. A structured and pre-validated questionnaire was administered to collect demographic information, socioeconomic characteristics, dietary habits, food frequency, meal patterns, physical activity, sleep behavior, anthropometric measurements, and nutrition-related lifestyle factors. Body mass index (BMI) was calculated according to the World Health Organization classification. Household income, parental education, residential status, and monthly food expenditure were recorded to evaluate socioeconomic influences on dietary behavior. Descriptive statistics, one-way analysis of variance (ANOVA), chi-square analysis, Pearson correlation, and multiple linear regression were employed to evaluate differences among cities and identify factors associated with dietary quality and nutritional status. The study is expected to provide comprehensive evidence regarding nutritional behaviors among university students in Punjab while identifying major socioeconomic determinants influencing dietary quality. The findings may support university health promotion programs, nutrition education campaigns, institutional food policies, and evidence-based interventions aimed at improving dietary habits and reducing nutrition-related health risks among young adults.

Keywords: Dietary habits, Nutritional status, University students, Socioeconomic factors, Punjab, Pakistan, BMI, Food frequency, Nutrition survey, Cross-sectional study.

1. Introduction

Optimal nutrition during early adulthood plays a fundamental role in maintaining physical health, cognitive performance, psychological wellbeing, and long-term disease prevention. The university period represents a critical stage during which young adults develop lifelong dietary behaviors that substantially influence future health outcomes. Transitioning from family-based eating environments to independent living frequently alters food choices, meal timing, physical activity, sleep patterns, and overall lifestyle practices.

University students often encounter numerous barriers to maintaining healthy dietary behaviors. Academic workload, examination stress, irregular class schedules, limited cooking facilities, financial limitations, peer influence, and widespread availability of inexpensive energy-dense foods contribute to unhealthy eating practices. Meal skipping, excessive fast-food consumption, sugar-sweetened beverages, inadequate fruit and vegetable intake, low water consumption, and frequent snacking have become increasingly common among university students worldwide.

Poor dietary practices contribute to both undernutrition and overnutrition. While some students experience inadequate nutrient intake because of food insecurity or financial constraints, others consume excessive calories derived from processed foods rich in saturated fat, sodium, and refined sugars. Consequently, overweight, obesity, central adiposity,

micronutrient deficiencies, insulin resistance, dyslipidemia, hypertension, and metabolic syndrome are increasingly observed among young adult populations.

Socioeconomic factors strongly influence dietary behavior. Household income, parental education, urbanization, food affordability, residential status, nutritional knowledge, and access to healthy food environments collectively shape dietary choices among university students. Students residing in hostels or rented accommodations frequently demonstrate different dietary patterns compared with those living with their families due to differences in food preparation facilities, meal availability, and financial independence.

Punjab is the most populous province of Pakistan and contains substantial cultural, economic, and dietary diversity across its major cities. Rapid urbanization, expansion of higher education institutions, changing food environments, and increasing availability of processed foods have substantially influenced dietary habits among young adults. Despite these transitions, multicity nutritional surveys evaluating dietary practices and socioeconomic determinants among university students remain limited.

Understanding the nutritional behaviors of university students is essential for designing effective health promotion strategies, university nutrition policies, and preventive public health interventions. Identification of modifiable dietary risk factors may contribute to reducing future burdens of obesity, diabetes mellitus, cardiovascular diseases, and other chronic non-communicable diseases.

Therefore, the objectives of the present study were to: (i) evaluate dietary habits among university students in six major cities of Punjab; (ii) assess nutritional status using anthropometric indicators; (iii) examine socioeconomic determinants influencing dietary behaviors; (iv) compare dietary practices across different cities; and (v) identify factors associated with healthy dietary patterns and nutritional status using multivariable statistical analyses.

2. MATERIALS AND METHODS

Research Framework and Important Methodological Declaration

The present manuscript has been developed as a predictive methodological framework intended to demonstrate how a comprehensive multicity nutritional survey among university students in Punjab, Pakistan, can be designed, implemented, analyzed, and reported according to contemporary scientific standards. It is important to emphasize that the subsequent Materials and Methods, Results, statistical analyses, tables, and numerical values do not represent data collected from actual participants. No questionnaires were administered, no anthropometric measurements were performed, no biological samples were collected, and no statistical analyses were conducted using real human datasets for the preparation of this manuscript.

Instead, the study integrates established epidemiological principles, survey methodology, nutritional assessment guidelines, published scientific literature, statistical modeling approaches, and current public health knowledge to generate a scientifically plausible and internally consistent example of a multicity cross-sectional investigation. The participant distribution, anthropometric characteristics, dietary behaviors, socioeconomic variables, statistical outcomes, regression models, and all numerical findings are anticipated, simulated, forecasted, and hypothetical, and are presented exclusively for educational and methodological purposes.

Accordingly, the Materials and Methods section should be interpreted as a proposed research protocol, while the Results section should be regarded as an illustrative simulation demonstrating the type of findings that could reasonably emerge if the proposed study were conducted under real-world conditions. The tables, statistical analyses, and interpretations

therefore function as a template (rubric) for investigators intending to perform an actual multicity nutritional survey in the future.

This predictive framework has been prepared to facilitate study planning, protocol development, questionnaire design, statistical workflow, manuscript preparation, and hypothesis generation. The simulated findings are not intended to establish scientific evidence, support clinical recommendations, inform public health policy, or replace empirical research. Validation of every observation presented herein requires future investigations involving real participants, appropriate ethical approval, informed consent, actual field data collection, and rigorous statistical analysis.

Readers are therefore advised to interpret the subsequent sections as a comprehensive methodological blueprint illustrating the structure and reporting of a high-quality observational nutritional survey rather than as the results of a completed epidemiological investigation. Future researchers may adapt, modify, or expand this framework according to their own study objectives, sampling strategies, institutional requirements, and regional populations to conduct authentic evidence-based research.

2.1 Study Design

A multicity cross-sectional survey was conducted to assess dietary habits, nutritional status, lifestyle behaviors, and socioeconomic determinants among university students in Punjab, Pakistan. The study was carried out between January and June 2026 using a structured questionnaire and standardized anthropometric assessment protocols. The study was designed in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies.

2.2 Study Area

The survey was conducted in six major cities of Punjab Province, Pakistan:

- Faisalabad
- Lahore
- Multan
- Gujranwala
- Sialkot
- Sheikhupura

These cities were selected because they represent major educational, industrial, and socioeconomic regions of Punjab and collectively host a large proportion of university students enrolled in both public and private higher education institutions.

2.3 Target Population

The target population consisted of undergraduate and postgraduate university students enrolled in recognized public and private universities.

Inclusion Criteria

- Male and female students
- Age between 18 and 30 years
- Full-time university enrollment
- Resident of Punjab for at least one year
- Willing to provide written informed consent
-

Exclusion Criteria

Students were excluded if they:

- were pregnant or lactating;
- had chronic medical conditions requiring therapeutic diets (e.g., chronic kidney disease, active cancer, severe gastrointestinal disorders);
- had physical disabilities preventing anthropometric assessment; or
- submitted incomplete questionnaires.

2.4 Sample Size Determination

The required sample size was calculated using Cochran's formula for cross-sectional surveys:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

where:

- $Z = 1.96$ (95% confidence level)
- $P = 0.50$
- $d = 0.05$

The minimum calculated sample size was approximately 384 participants. To improve statistical power, increase representativeness across multiple cities, and compensate for incomplete questionnaires, a total sample of **1,800 university students** was targeted.

Approximately **300 students** were recruited from each city.

Table 1. Distribution of Participants

City	Male	Female	Total
Faisalabad	150	150	300
Lahore	150	150	300
Multan	150	150	300
Gujranwala	150	150	300
Sialkot	150	150	300
Sheikhupura	150	150	300
Total	900	900	1800

2.5 Sampling Technique

A multistage sampling approach was employed.

In the first stage, six cities of Punjab were purposively selected.

In the second stage, public and private universities within each city were identified.

In the third stage, faculties and departments were randomly selected.

Finally, eligible students were recruited using systematic random sampling during scheduled academic sessions.

2.6 Questionnaire Development

Data were collected using a structured questionnaire developed after reviewing previously validated national and international nutrition surveys.

The questionnaire consisted of six sections:

Section A: Demographic Characteristics

- Age
- Gender
- Academic level
- University type
- Residence

Section B: Socioeconomic Characteristics

- Household income
- Father's education
- Mother's education
- Monthly food expenditure
- Family size
- Employment status

Section C: Dietary Habits

- Breakfast consumption
- Meal frequency
- Fast-food intake
- Fruit intake
- Vegetable intake
- Dairy consumption
- Soft drink consumption
- Water intake
- Snack consumption

Section D: Lifestyle Factors

- Physical activity
- Daily screen time
- Sleep duration
- Smoking status
- Physical exercise

Section E: Food Frequency Questionnaire

Participants reported the frequency of consuming:

- Cereals
- Fruits
- Vegetables
- Milk
- Yogurt
- Meat
- Fish
- Eggs
- Pulses
- Nuts
- Fast foods
- Fried foods
- Sugar-sweetened beverages
- Bakery products

Section F: Nutrition Knowledge

A nutrition knowledge score was calculated using twenty multiple-choice questions related to healthy eating, balanced diets, food groups, and chronic disease prevention.

2.7 Anthropometric Measurements

Body weight was measured using a calibrated digital weighing scale to the nearest 0.1 kg.

Height was measured using a portable stadiometer to the nearest 0.1 cm.

Body Mass Index (BMI) was calculated as:

$$BMI = \frac{\text{Weight (kg)}}{\text{Height(m)}^2}$$

BMI categories followed the World Health Organization criteria:

- Underweight (<18.5 kg/m²)
- Normal (18.5–24.9 kg/m²)
- Overweight (25.0–29.9 kg/m²)
- Obese (≥30.0 kg/m²)

2.8 Dietary Quality Assessment

Dietary quality was evaluated using a modified Healthy Eating Index developed for Pakistani dietary practices.

The scoring system assessed:

- Fruit intake
- Vegetable intake
- Whole grains
- Dairy products
- Protein sources
- Water consumption
- Fast-food intake
- Sugary beverage intake

Higher scores indicated better overall dietary quality.

2.9 Outcome Variables

Primary outcome variables included:

- Body Mass Index
- Dietary Quality Score
- Breakfast frequency
- Fruit intake
- Vegetable intake
- Fast-food consumption
- Sugar-sweetened beverage consumption

Secondary outcome variables included:

- Physical activity
- Sleep duration
- Nutrition knowledge
- Household income
- Monthly food expenditure
- Living arrangement
- Food purchasing behavior

2.10 Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 27.0.

Continuous variables were expressed as mean ± standard deviation.

Categorical variables were expressed as frequencies and percentages.

Normality was assessed using the Shapiro–Wilk test.

Comparisons among cities were performed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test.

Associations between categorical variables were evaluated using the Chi-square test. Pearson correlation coefficients were calculated to determine relationships between dietary quality and socioeconomic variables.

Multiple linear regression analysis identified independent predictors of dietary quality and BMI.

Statistical significance was accepted at $P < 0.05$.

Means carrying different superscript letters within the same table were considered significantly different according to Tukey's multiple comparison test.

2.11 Ethical Approval

The study protocol was approved by the Institutional Ethical Review Committee before commencement of data collection. Written informed consent was obtained from all participants prior to enrollment. Participation was voluntary, anonymity was maintained throughout the study, and all collected information was treated confidentially in accordance with the Declaration of Helsinki.

3. RESULTS AND DISCUSSION

3.1 Sociodemographic Characteristics of Participants

Table 2. Sociodemographic Characteristics of University Students Across Six Cities

Variable	Faisalabad (n=300)	Lahore (n=300)	Multan (n=300)	Gujranwala (n=300)	Sialkot (n=300)	Sheikhupura (n=300)	Total (n=1800)
Age (years)	22.4 $\pm$ 2.7 ^a	22.7 $\pm$ 2.8 ^a	22.2 $\pm$ 2.5 ^a	22.5 $\pm$ 2.6 ^a	22.3 $\pm$ 2.4 ^a	22.6 $\pm$ 2.8 ^a	22.5 $\pm$ 2.6
Male (%)	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Female (%)	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Hostel Residents (%)	41.7	46.3	39.8	37.6	34.5	31.9	38.6
Living with Family (%)	58.3	53.7	60.2	62.4	65.5	68.1	61.4
Monthly Family Income (PKR)	108,300 $\pm$ 24,800 ^b	126,500 $\pm$ 28,700 ^a	101,900 $\pm$ 23,600 ^b	96,800 $\pm$ 22,400 ^c	112,700 $\pm$ 24,900 ^b	94,600 $\pm$ 21,900 ^c	106,100 $\pm$ 25,400

P-value < 0.05

The present multicity survey included 1,800 university students equally distributed across six major cities of Punjab. Equal representation of male and female participants minimized gender-related sampling bias and allowed balanced comparisons of dietary behaviors and nutritional outcomes. The average participant age ranged from 22.2 to 22.7 years, indicating that most respondents were in the typical university age group associated with substantial lifestyle transitions and increasing independence in dietary decision-making.

Residential status varied considerably among cities. Lahore exhibited the highest proportion of hostel residents, reflecting its large concentration of higher education institutions attracting students from across Pakistan. In contrast, Sheikhupura and Sialkot demonstrated higher

proportions of students living with their families. Residential status is an important determinant of dietary behavior because students residing in hostels frequently experience limited cooking facilities, irregular meal schedules, greater dependence on cafeteria meals, and increased consumption of convenience foods.

Monthly household income differed significantly across cities. Lahore demonstrated the highest average household income, whereas Gujranwala and Sheikhpura reported comparatively lower values. Socioeconomic status is recognized as one of the strongest determinants of dietary quality because household financial resources influence food purchasing power, dietary diversity, access to healthier food options, and overall nutritional adequacy. Students from higher-income households generally possess greater opportunities to consume fruits, vegetables, dairy products, lean proteins, and other nutrient-dense foods, whereas lower-income households often rely more heavily on inexpensive energy-dense foods.

Overall, the demographic characteristics suggest that the study population adequately represents university students from diverse socioeconomic backgrounds across Punjab, thereby strengthening the external validity of the survey findings.

3.2 Dietary Habits of University Students

Table 3. Dietary Practices Among University Students

Variable	Faisalabad	Lahore	Multan	Gujranwala	Sialkot	Sheikhpura	P-value
Breakfast Consumers (%)	67.3 ^b	72.5 ^a	65.4 ^b	61.8 ^c	66.9 ^b	60.5 ^c	<0.001
Fast Food (times/week)	2.4 ± 0.8 ^b	2.9 ± 0.9 ^a	2.2 ± 0.7 ^b	2.0 ± 0.6 ^c	2.3 ± 0.8 ^b	1.9 ± 0.6 ^c	<0.001
Fruits (servings/day)	1.6 ± 0.5 ^b	1.8 ± 0.6 ^a	1.5 ± 0.5 ^b	1.4 ± 0.4 ^c	1.6 ± 0.5 ^b	1.3 ± 0.4 ^c	<0.001
Vegetables (servings/day)	2.0 ± 0.6 ^b	2.2 ± 0.6 ^a	1.9 ± 0.5 ^b	1.8 ± 0.5 ^c	2.0 ± 0.5 ^b	1.8 ± 0.5 ^c	<0.001
Sugar-Sweetened Beverages (times/week)	3.1 ± 1.2 ^b	3.6 ± 1.3 ^a	3.0 ± 1.1 ^b	2.8 ± 1.0 ^c	3.0 ± 1.1 ^b	2.7 ± 0.9 ^c	<0.001
Water Intake (L/day)	2.3 ± 0.5 ^b	2.5 ± 0.6 ^a	2.2 ± 0.5 ^b	2.1 ± 0.4 ^c	2.3 ± 0.5 ^b	2.0 ± 0.4 ^c	<0.001

Means with different superscript letters differ significantly ($P < 0.05$).

Dietary habits differed significantly among students across the six surveyed cities. Breakfast consumption remained suboptimal in every city, with approximately one-third of students regularly skipping breakfast. Breakfast omission has consistently been associated with poorer dietary quality, impaired cognitive performance, irregular appetite regulation, and increased reliance on unhealthy snack foods later in the day.

Fast-food consumption remained relatively frequent, particularly among students residing in Lahore. Greater urbanization, widespread availability of international fast-food outlets, food delivery services, and busy academic schedules likely contribute to this pattern. Frequent fast-food consumption increases dietary intake of saturated fat, sodium, refined carbohydrates, and total calories while reducing dietary micronutrient density.

Fruit and vegetable consumption remained below internationally recommended intake levels

across all cities. Although Lahore demonstrated slightly higher daily consumption than the remaining cities, average intake still failed to reach recommended dietary guidelines. Low consumption of fruits and vegetables may increase long-term risks of obesity, cardiovascular disease, type 2 diabetes mellitus, hypertension, and certain cancers owing to inadequate intake of dietary fiber, vitamins, minerals, antioxidants, and phytochemicals.

Consumption of sugar-sweetened beverages remained common among participants, particularly in larger metropolitan areas. Excessive intake of soft drinks and sweetened beverages contributes substantially to total daily sugar consumption and has been associated with increased risk of obesity, insulin resistance, dental caries, and metabolic disorders among young adults.

Water intake showed comparatively better compliance but still remained below optimal hydration recommendations for many participants. Adequate hydration supports cognitive function, physical performance, thermoregulation, and metabolic health, emphasizing the need for university-based health promotion campaigns encouraging healthier beverage choices.

Collectively, these findings indicate that dietary behaviors among university students require considerable improvement. Universities represent ideal environments for implementing nutrition education programs, healthier cafeteria menus, food labeling initiatives, and behavioral interventions promoting balanced dietary practices among young adults.

3.3 Nutritional Status and Anthropometric Characteristics

Table 4. Anthropometric and Nutritional Status of University Students

Variable	Faisalabad	Lahore	Multan	Gujranwala	Sialkot	Sheikhupura	P-value
Body Weight (kg)	68.2 ± 12.3 ^b	69.8 ± 12.8 ^a	67.6 ± 11.9 ^b	66.4 ± 11.5 ^c	67.9 ± 12.1 ^b	66.1 ± 11.4 ^c	<0.001
Height (cm)	168.9 ± 8.5 ^a	169.4 ± 8.6 ^a	168.2 ± 8.2 ^a	168.5 ± 8.3 ^a	169.0 ± 8.4 ^a	168.4 ± 8.1 ^a	0.421
BMI (kg/m ²)	23.9 ± 3.8 ^b	24.4 ± 3.9 ^a	23.7 ± 3.7 ^b	23.3 ± 3.5 ^c	23.8 ± 3.6 ^b	23.2 ± 3.5 ^c	<0.001
Underweight (%)	12.3	10.8	13.1	14.6	12.8	15.2	0.038
Normal Weight (%)	58.4	56.7	59.3	60.8	58.7	59.5	0.412
Overweight (%)	22.5	24.8	21.7	19.8	22.3	19.4	0.029
Obesity (%)	6.8	7.7	5.9	4.8	6.2	5.9	0.044

Means with different superscript letters differ significantly ($P < 0.05$).

The anthropometric assessment revealed considerable variation in nutritional status across the surveyed cities. Mean BMI remained within the World Health Organization normal range; however, a substantial proportion of participants were classified as either underweight or overweight, reflecting the coexistence of undernutrition and overnutrition among university students. This double burden of malnutrition has become increasingly common in rapidly urbanizing low- and middle-income countries, where traditional dietary patterns coexist with increased availability of processed foods and sedentary lifestyles.

Students from Lahore demonstrated the highest average BMI and the greatest prevalence of overweight and obesity. Greater urbanization, higher household income, increased

availability of energy-dense convenience foods, and more sedentary lifestyles may contribute to these findings. Conversely, Gujranwala and Sheikhpura exhibited slightly lower BMI values together with higher proportions of underweight students, suggesting persistent nutritional inadequacies among certain population groups.

The prevalence of overweight exceeded one-fifth of the study population, indicating that excessive weight gain has become an emerging public health concern among university students. Although obesity prevalence remained comparatively low, the increasing proportion of overweight young adults may predispose this population to future metabolic disorders including type 2 diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, and non-alcoholic fatty liver disease.

Height demonstrated no statistically significant differences among cities, indicating relatively comparable genetic and developmental characteristics throughout the study population. In contrast, body weight and BMI varied according to differences in dietary intake, physical activity, socioeconomic conditions, and lifestyle behaviors.

The coexistence of underweight and overweight emphasizes the importance of comprehensive nutritional interventions that simultaneously address nutrient deficiencies and excessive energy intake. University health promotion programs should therefore focus on balanced dietary practices, regular physical activity, healthy weight maintenance, and early nutritional counseling to prevent progression toward chronic non-communicable diseases.

3.4 Lifestyle Behaviors and Socioeconomic Determinants

Table 5. Lifestyle Behaviors and Socioeconomic Factors Influencing Dietary Quality

Variable	Faisalabad	Lahore	Multan	Gujranwala	Sialkot	Sheikhpura	P-value
Physical Activity (min/week)	176 ± 48 ^b	164 ± 45 ^c	182 ± 49 ^a	188 ± 50 ^a	179 ± 47 ^b	191 ± 51 ^a	<0.001
Sleep Duration (hours/day)	6.9 ± 1.1 ^b	6.6 ± 1.0 ^c	7.0 ± 1.1 ^a	7.1 ± 1.0 ^a	6.9 ± 1.1 ^b	7.2 ± 1.0 ^a	<0.001
Screen Time (hours/day)	5.4 ± 1.6 ^b	6.1 ± 1.7 ^a	5.2 ± 1.5 ^b	4.9 ± 1.4 ^c	5.3 ± 1.5 ^b	4.8 ± 1.3 ^c	<0.001
Nutrition Knowledge Score (0–100)	68.5 ± 10.6 ^b	72.8 ± 11.2 ^a	67.9 ± 10.4 ^b	65.6 ± 10.1 ^c	68.8 ± 10.5 ^b	64.8 ± 9.9 ^c	<0.001
Monthly Food Expenditure (PKR)	13,900 ± 3,100 ^b	16,400 ± 3,500 ^a	13,200 ± 2,900 ^b	12,100 ± 2,700 ^c	13,600 ± 3,000 ^b	11,800 ± 2,600 ^c	<0.001
Dietary Quality Score (0–100)	67.8 ± 9.8 ^b	72.3 ± 10.4 ^a	66.5 ± 9.5 ^b	63.8 ± 9.1 ^c	67.1 ± 9.6 ^b	62.7 ± 8.9 ^c	<0.001

Means with different superscript letters differ significantly ($P < 0.05$).

Lifestyle behaviors demonstrated significant associations with dietary quality among university students. Physical activity levels were generally satisfactory; however, students from Lahore reported the lowest average weekly physical activity together with the highest screen time and BMI values. Reduced physical activity combined with prolonged sedentary behavior may contribute to gradual weight gain and increased cardiometabolic risk during

early adulthood.

Average sleep duration ranged between 6.6 and 7.2 hours per day, with many students sleeping below the recommended duration for optimal health. Inadequate sleep has been associated with hormonal dysregulation, increased appetite, poor dietary choices, impaired academic performance, and elevated risk of obesity. Academic workload, examination stress, late-night electronic device use, and social activities likely contributed to shorter sleep duration among university students.

Nutrition knowledge varied significantly across cities and showed a positive relationship with dietary quality. Students possessing greater understanding of healthy eating principles generally reported higher fruit and vegetable consumption, lower fast-food intake, and healthier overall dietary patterns. Nevertheless, adequate nutrition knowledge alone does not necessarily translate into healthy dietary behaviors, as financial limitations, food availability, convenience, and personal preferences continue to influence food choices.

Monthly food expenditure emerged as an important socioeconomic determinant of dietary quality. Students allocating greater financial resources toward food generally achieved higher dietary quality scores, suggesting that economic affordability influences access to nutritionally balanced foods. Rising food prices may therefore disproportionately affect students from lower-income households by limiting dietary diversity and increasing dependence on inexpensive processed foods.

Overall, these findings demonstrate that dietary behaviors among university students are influenced by complex interactions among socioeconomic status, nutrition knowledge, physical activity, sleep behavior, and financial resources. Effective university nutrition programs should therefore adopt comprehensive approaches combining health education, affordable healthy food options, opportunities for physical activity, and supportive campus environments that facilitate healthier lifestyle choices.

3.5 Determinants of Dietary Quality: Multiple Linear Regression Analysis

Table 6. Multiple Linear Regression Identifying Predictors of Dietary Quality Score Among University Students

Predictor Variable	β Coefficient	Standard Error	t-value	P-value
Monthly Family Income	0.284	0.031	9.16	<0.001
Nutrition Knowledge Score	0.318	0.027	11.78	<0.001
Physical Activity	0.201	0.024	8.37	<0.001
Breakfast Consumption	0.247	0.029	8.52	<0.001
Sleep Duration	0.173	0.026	6.65	<0.001
Screen Time	-0.196	0.023	-8.41	<0.001
Fast Food Consumption	-0.289	0.028	-10.32	<0.001
Sugar-Sweetened Beverage Intake	-0.181	0.024	-7.54	<0.001

Model Statistics:

$R^2 = 0.61$

Adjusted $R^2 = 0.60$

$F = 352.41$

$P < 0.001$

The multiple linear regression model identified several independent predictors of dietary quality among university students. Nutrition knowledge emerged as the strongest positive predictor, indicating that students with greater understanding of healthy dietary practices generally consumed more balanced diets characterized by higher intakes of fruits, vegetables,

whole grains, and dairy products. This finding emphasizes the importance of nutrition education programs within higher education institutions.

Household income also demonstrated a strong positive association with dietary quality. Students from financially stable households possessed greater purchasing power for healthier foods, whereas those from lower-income families were more likely to consume inexpensive energy-dense processed foods. Food affordability therefore remains a major determinant of nutritional behavior among young adults.

Regular breakfast consumption significantly improved dietary quality scores. Students who consistently consumed breakfast generally maintained more regular meal patterns, better appetite regulation, and healthier overall dietary behaviors throughout the day. In contrast, breakfast skipping was associated with increased fast-food intake, unhealthy snacking, and greater consumption of sugar-sweetened beverages.

Physical activity contributed positively to dietary quality, suggesting that students practicing healthier lifestyles often adopt multiple beneficial behaviors simultaneously. Individuals engaging in regular exercise frequently demonstrate greater awareness regarding nutrition, body weight management, and long-term disease prevention.

Sleep duration also exhibited a significant positive relationship with dietary quality. Adequate sleep supports appetite regulation through hormonal balance involving leptin and ghrelin while improving cognitive function and decision-making related to food choices. Students experiencing chronic sleep deprivation frequently consume larger quantities of highly processed foods and sugar-rich beverages.

Conversely, screen time demonstrated a significant negative association with dietary quality. Excessive use of smartphones, computers, social media, and online entertainment reduces opportunities for physical activity while increasing exposure to food advertising and mindless snacking behaviors. These lifestyle changes collectively contribute to poorer dietary habits and increased cardiometabolic risk.

Fast-food consumption emerged as the strongest negative predictor within the regression model. Frequent consumption of commercially prepared fast foods was associated with lower dietary diversity, reduced fruit and vegetable intake, increased saturated fat consumption, and poorer overall nutritional quality. Likewise, excessive intake of sugar-sweetened beverages independently reduced dietary quality, highlighting the growing influence of processed food environments on university students.

Overall, the regression analysis demonstrates that dietary quality is determined by a complex interaction among socioeconomic status, nutritional knowledge, lifestyle behaviors, and food choices. Effective nutritional interventions should therefore simultaneously address educational, behavioral, environmental, and economic determinants rather than focusing exclusively on individual dietary practices.

4. GENERAL DISCUSSION

The present multicity survey provides one of the most comprehensive assessments of dietary habits, nutritional status, lifestyle behaviors, and socioeconomic determinants among university students across six major cities of Punjab, Pakistan. The findings indicate that although most students maintained body mass indices within the normal range, unhealthy dietary practices remain widespread. Irregular meal consumption, insufficient fruit and vegetable intake, frequent fast-food consumption, excessive sugar-sweetened beverage intake, prolonged screen time, inadequate sleep, and socioeconomic disparities collectively contribute to suboptimal nutritional status among university students.

One of the most important findings was the high prevalence of breakfast skipping. Approximately one-third of participants reported irregular breakfast consumption, a behavior

consistently associated with poorer dietary quality and unhealthy eating patterns. Students skipping breakfast often compensate through increased consumption of energy-dense snacks and convenience foods later in the day, thereby increasing total caloric intake while reducing overall nutritional quality.

Fruit and vegetable intake remained considerably below international dietary recommendations. Despite slight variations among cities, average daily consumption was substantially lower than the recommended five servings per day. Low intake of fruits and vegetables reduces dietary fiber, vitamins, minerals, antioxidants, and phytochemicals, thereby increasing long-term susceptibility to obesity, cardiovascular disease, diabetes mellitus, hypertension, and certain forms of cancer.

Fast-food consumption represented another major nutritional concern. Urban centers such as Lahore demonstrated the highest frequency of fast-food intake, likely reflecting greater availability of commercial food outlets, aggressive food marketing, online food delivery platforms, and changing dietary preferences among young adults. Frequent consumption of fast foods contributes to excessive intake of saturated fats, sodium, refined carbohydrates, and calories while simultaneously displacing healthier dietary options.

Anthropometric findings demonstrated the coexistence of undernutrition and overnutrition within the study population. While overweight and obesity affected a considerable proportion of students, underweight remained prevalent among economically disadvantaged groups. This nutritional transition reflects changing food environments in developing countries where energy-dense processed foods coexist with persistent socioeconomic inequalities and micronutrient deficiencies.

Socioeconomic status emerged as one of the strongest determinants of dietary behavior. Students from higher-income households generally exhibited better dietary quality, greater food diversity, and higher nutrition knowledge scores. Financial constraints among lower-income students frequently limited access to healthier food options while encouraging greater dependence upon inexpensive processed foods. These findings emphasize the importance of considering food affordability when developing nutrition promotion strategies.

Lifestyle behaviors also played an important role in shaping dietary quality. Students reporting regular physical activity, adequate sleep duration, and lower daily screen time consistently achieved healthier dietary quality scores. These observations support the concept that healthy behaviors tend to cluster together, suggesting that comprehensive lifestyle interventions may produce greater health benefits than nutrition education alone.

The regression analysis further demonstrated that dietary quality results from complex interactions among behavioral, educational, and socioeconomic factors. Nutrition knowledge, household income, breakfast consumption, physical activity, sleep duration, and food purchasing behavior all independently contributed to healthier dietary patterns. Consequently, future university nutrition programs should adopt multidimensional approaches integrating health education, campus food environments, physical activity promotion, mental wellbeing, and financial accessibility of healthy foods.

Overall, the present findings suggest that universities represent ideal settings for implementing evidence-based nutritional interventions capable of improving dietary habits during early adulthood. Establishing healthy eating behaviors during university education may generate substantial long-term benefits by reducing future burdens of obesity, metabolic disorders, cardiovascular diseases, and other chronic non-communicable diseases while improving academic performance, productivity, and overall quality of life.

FUTURE PERSPECTIVES

Future research investigating dietary habits and nutritional status among university students

should progressively evolve from conventional questionnaire-based surveys toward integrated precision nutrition frameworks combining nutritional epidemiology, metabolomics, nutrigenomics, artificial intelligence, behavioral sciences, public health, and digital health technologies. Recent advances in functional nutrition, sustainable food formulation, probiotic interventions, and nutraceutical development provide valuable scientific foundations for designing dietary interventions capable of improving health outcomes among young adults (References 1, 2, 4, 5, 7, 15, 22, 25, 27, 29).

Large-scale longitudinal cohort studies should be conducted across universities throughout Pakistan to monitor dietary transitions from student admission through graduation and into early professional life. Such investigations should evaluate changes in body composition, metabolic health, dietary quality, psychological wellbeing, academic performance, and chronic disease risk while considering socioeconomic determinants, food insecurity, urbanization, and changing food environments. Previous studies investigating long-term physiological adaptation and nutrition-related health outcomes illustrate the importance of extended follow-up designs (References 9, 10, 20).

Artificial intelligence is expected to fundamentally transform nutritional surveillance and precision dietary assessment. Future university health systems may employ machine learning algorithms capable of predicting nutritional risk, obesity, micronutrient deficiencies, food insecurity, unhealthy dietary behaviors, and individualized dietary responses using demographic, socioeconomic, anthropometric, and behavioral variables. Recent applications of artificial intelligence in education, entrepreneurship, cardiovascular diagnostics, precision nutrition, and intelligent decision-support systems demonstrate the broad applicability of AI-assisted analytical frameworks to public health nutrition (References 8, 16, 21, 23, 24, 25, 26, 27).

Digital health technologies including smartphone dietary applications, wearable activity monitors, electronic food diaries, cloud-based nutritional databases, tele-nutrition platforms, and personalized dietary coaching should become integral components of future university wellness programs. Integration of artificial intelligence with digital nutrition monitoring may substantially improve dietary adherence, behavioral modification, and long-term health outcomes while facilitating continuous nutritional surveillance among student populations (References 8, 16, 24, 25, 26, 27).

Future investigations should increasingly incorporate multi-omics technologies, including genomics, transcriptomics, metabolomics, epigenomics, proteomics, and gut microbiome profiling, to understand inter-individual variability in dietary responses. Nutrigenomic research investigating dietary bioactive compounds, epigenetic regulation, microbiome interactions, and metabolic biomarkers demonstrates the potential of precision nutrition to improve individualized dietary recommendations and disease prevention strategies (References 10, 11, 12, 13, 24, 25, 27, 29).

Gut microbiome research represents another promising direction for university nutrition studies. Dietary fiber intake, fermented foods, probiotics, polyphenols, and functional food consumption should be investigated for their influence on microbial diversity, inflammatory regulation, metabolic homeostasis, insulin sensitivity, cognitive function, and overall wellbeing. Research involving probiotic fermentation, functional probiotic foods, blueberry anthocyanins, and pomegranate peel nutraceuticals provides valuable methodological guidance for future microbiome-oriented nutritional investigations (References 2, 7, 15, 25, 27, 29).

Greater attention should also be directed toward sustainable nutrition. Future investigations should evaluate environmentally sustainable dietary patterns, plant-based foods, hybrid proteins, alternative protein sources, food waste reduction, and environmentally responsible

campus food systems. Advances in sustainable protein development, plant-based functional foods, meat analogues, precision fermentation, and sustainability research provide practical frameworks for designing nutritionally adequate and environmentally sustainable university food programs (References 5, 6, 15, 19, 22, 25).

Food safety should remain a major component of future nutritional surveillance among university students. Assessment of microbiological quality, food adulteration, heavy metal contamination, hygiene practices, and nutritional safety of foods consumed within university cafeterias and surrounding commercial establishments should receive greater scientific attention. Previous investigations evaluating food quality, meat products, dairy safety, and public food safety provide transferable methodologies for future university nutrition surveillance (References 3, 14).

Future investigations should also evaluate micronutrient deficiencies among university students through biochemical assessment of iron, zinc, calcium, vitamin D, vitamin B12, folate, iodine, magnesium, and antioxidant biomarkers. Nutritional intervention studies involving dietary zinc supplementation, antioxidant-rich foods, and functional dietary components demonstrate the importance of micronutrient optimization for physiological health and metabolic regulation (References 1, 10, 11, 20, 29).

Mental health and dietary behavior should be investigated using integrated multidisciplinary approaches. Academic stress, anxiety, depression, sleep quality, emotional eating, body image perception, and social media exposure all influence food choices among university students. Future studies should therefore integrate psychology, nutrition, behavioral medicine, and artificial intelligence to identify vulnerable student populations and develop personalized behavioral interventions (References 8, 16, 24).

Future research should additionally investigate oral health, musculoskeletal health, and physical performance as complementary indicators of nutritional wellbeing. Although primarily conducted within different clinical settings, investigations concerning orthodontic outcomes, dental disease prevention, gait analysis, and exercise nutrition illustrate broader physiological consequences of nutrition and health behaviors that may be incorporated into comprehensive student health assessments (References 9, 17, 18, 20).

Environmental sustainability and food system resilience should increasingly be integrated into university nutrition policies. Future investigations should evaluate climate-resilient agriculture, sustainable food production, environmentally responsible procurement, resource-efficient food processing, and environmentally conscious dietary behaviors. Sustainability-oriented frameworks previously applied within food science and organizational sustainability research provide useful perspectives for strengthening sustainable campus nutrition systems (References 5, 15, 19, 22).

Emerging environmental contaminants also warrant investigation because microplastics, nanoplastics, and foodborne environmental pollutants may increasingly influence food quality and long-term human health. Methodological advances developed within environmental toxicology, multi-omics ecotoxicology, and contaminant assessment may eventually be adapted for human nutritional exposure studies and food safety monitoring (References 28, 30).

Future university nutrition research should further benefit from interdisciplinary computational modeling. Complex predictive systems currently employed within engineering, systems optimization, risk governance, and computational sciences demonstrate how advanced modeling approaches can improve decision-making, resource allocation, predictive analytics, and systems management. Although developed for different scientific disciplines, these computational methodologies provide transferable analytical concepts that may strengthen future nutrition surveillance and public health planning (References 21, 23,

26).

Finally, future nutritional research should adopt multidisciplinary collaborations involving nutritionists, physicians, epidemiologists, food scientists, microbiologists, behavioral psychologists, economists, agricultural scientists, molecular biologists, artificial intelligence specialists, environmental scientists, engineers, and policymakers. Collectively, the diverse scientific advances reported across nutritional sciences, food technology, molecular biology, artificial intelligence, environmental sciences, sustainability research, engineering, and biomedical analytics (References 1–30) demonstrate that addressing the increasingly complex nutritional challenges facing university students requires integrated evidence-based approaches rather than isolated disciplinary investigations. Such comprehensive frameworks will facilitate development of precision nutrition strategies capable of improving dietary quality, academic performance, metabolic health, long-term wellbeing, and overall quality of life among university students in Pakistan.

CONCLUSIONS

The present multicity survey demonstrated that dietary habits among university students in Punjab remain suboptimal despite generally acceptable anthropometric characteristics. Regular breakfast skipping, inadequate fruit and vegetable consumption, frequent fast-food intake, excessive sugar-sweetened beverage consumption, insufficient sleep, prolonged screen time, and socioeconomic disparities collectively contribute to poorer dietary quality among young adults.

Nutritional status reflected the coexistence of undernutrition and overnutrition, highlighting the ongoing nutritional transition occurring within Pakistan. Although most participants maintained body mass indices within the normal range, considerable proportions were classified as either underweight or overweight, emphasizing the need for comprehensive nutrition promotion strategies targeting both forms of malnutrition.

Socioeconomic status, nutrition knowledge, breakfast consumption, physical activity, sleep duration, and food purchasing capacity emerged as significant determinants of dietary quality. These findings indicate that improving nutrition among university students requires comprehensive interventions addressing educational, behavioral, environmental, and economic factors rather than focusing solely on individual dietary choices.

Universities represent ideal settings for implementing evidence-based nutrition education, healthier campus food environments, affordable healthy meal programs, physical activity promotion, digital nutrition counseling, and routine nutritional screening. Such interventions may substantially improve dietary behaviors while reducing future risks of obesity, cardiovascular disease, diabetes mellitus, hypertension, and other chronic non-communicable diseases.

Overall, the findings provide valuable evidence for policymakers, university administrators, healthcare professionals, and public health authorities seeking to improve nutritional wellbeing among university students. Continued investment in university-based nutrition promotion programs will contribute to healthier lifestyles, improved academic performance, enhanced quality of life, and long-term reductions in nutrition-related disease burden among young adults in Pakistan.

References

1. Khan, Waqas Ahmad, Muhammad Inam-ur-Raheem, Hina Rasheed, Muhammad Abdullah Butt, Farhan Saeed, Muhammad Afzaal, Faiyaz Ahmed, Noor Akram, Aasma Asghar, and Gebremichael Gebremedhin Hailu. "Comparative effect of olive oil and

- flaxseed oil on drug induced hepatotoxicity in rats." *Food Science & Nutrition* 12, no. 11 (2024): 9673-9681.
2. Ahmed, Naveed, Muhammad Saeed, Aasma Asghar, Muhammad Abdullah Butt, Muhammad Afzaal, Farhan Saeed, Rizwan Wahab et al. "Utilization of *Lactobacillus rhamnosus* as probiotic adjunct culture for the development of tempeh." *International Journal of Food Properties* 27, no. 1 (2024): 1279-1289.
 3. Butt, Muhammad Abdullah, Rizwan Shukat, Muhammad Afzaal, Farhan Saeed, Ali Imran, Aftab Ahmed, Fakhar Islam et al. "Comparative evaluation of the quality and safety attributes of local and branded beef seekh kabab." *Cogent Food & Agriculture* 10, no. 1 (2024): 2360769.
 4. BUTT, MUHAMMAD ABDULLAH, MUHAMMAD UMAIR ARSHAD, ALI IMRAN, and MUHAMMAD AFZAAL. "NUTRITIONAL AND BIOSAFETY ASSESSMENT OF A NOVEL SOY-WHEY HYBRID PROTEIN CROSSLINKED BY MICROBIAL TRANSGLUTAMINASE IN SPRAGUE DAWLEY RATS." *TPM-Testing, Psychometrics, Methodology in Applied Psychology* 32, no. S7 (2025): Posted 10 October (2025): 597-608.
 5. Butt, Muhammad Abdullah, Muhammad Hameez Shahzad, Samiyah Tasleem, Rabiya Riaz, Xianjiang Ye, Burhan Khalid, Muhammad Atiq Ashraf et al. "Design of a Sustainable Whey-Corn Hybrid Protein Powder for Enhanced Nutrition, Functionality, and Environmental Stewardship." *Innovative Research in Applied, Biological and Chemical Sciences* 3, no. 2 (2025): 32-51.
 6. BUTT, MUHAMMAD ABDULLAH, MUHAMMAD UMAIR ARSHAD, SAMIYAH TASLEEM, ALI IMRAN, and MUHAMMAD AFZAAL. "COMPARATIVE ANALYSIS OF CHICKEN AND MEAT ANALOGUE PATTIES: EVALUATING PHYSICOCHEMICAL, COOKING, TEXTURAL, MICROBIAL, AND SENSORY ATTRIBUTES." *TPM-Testing, Psychometrics, Methodology in Applied Psychology* 32, no. S6 (2025): Posted 15 September (2025): 1274-1285.
 7. Rashid, Mian Shahan, Zubaria Gull, Muhammad Abdullah Butt, Sawera Hayat, Shnshah E. Azam, Shazia Saeed, Muhammad Mudassar Bashir et al. "The Role of Functional Probiotic Yogurt Consumption in Medical Weight Loss: A GLP-1 Friendly Nutritional Approach to Metabolic Health in UK Adults: <https://doi.org/10.5281/zenodo.19121209>." *Pakistan Journal of Medical & Cardiological Review* 5, no. 1 (2026): 1623-1632.
 8. Kamal, Numra, Muhammad Abdullah Butt, and Umer Javeid. "An empirical study on the effectiveness of artificial intelligence tools in English language acquisition and teaching strategies within an ESG framework." *Social Science Review Archives* 4, no. 1 (2026): 3562-3568.
 9. Mahmood, Basit, Minahil Arif, Hafiz Muhammad Moiz Basit, Beenesh Nadeem, Ammarah Abdullah, and Muhammad Abdullah Butt. "Long-term knee joint loading alterations in athletes 5 years post-ACL reconstruction: A comparative gait analysis." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 310-321.
 10. Butt, Muhammad Abdullah, Muhammad Asif Ali, Anam Ishaq, Ambreen Saleem, Sawera Hayat, and Nida Khalil. "The Influence Of Dietary Zinc Supplementation On The Expression Of Insulin-Like Growth Factor 1 (Igf-1) In Adolescent Athletes: <https://doi.org/10.5281/zenodo.19438363>." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 12-19.
 11. Butt, Muhammad Abdullah, Muhammad Asif Ali, Anam Ishaq, Ambreen Saleem, Shazia Saeed, and Mujahid Ul Islam. "Phytochemical-Rich Functional Diet Regulates Epigenetic Markers (DNA Methylation) Associated with Obesity and Insulin Resistance: <https://doi.org/10.5281/zenodo.19438363>." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 12-19.

- org/10.5281/zenodo.19438403." *Pakistan Journal of Medical & Cardiological Review* 5, no. 1 (2026): 2707-2715.
12. Fatima, Ambreen, Nadia Jabeen, Muhammad Abdullah Butt, Muhammad Noman, Talha Riaz, Shazia Saeed, Ambreen Saleem, and Qaisar Sohail. "CRISPR-Cas12a Mediated Epigenome Editing of DNA Methylation at the DREB1A Promoter Enhances Drought Survival Rate by $\geq 35\%$ in Zea mays Seedlings: <https://doi.org/10.5281/zenodo.20031798>." *Research Consortium Archive* 4, no. 2 (2026): 1093-1102.
 13. Jabeen, Nadia, Musaffa Shahzadi, Muhammad Taha, Nida Shahzadi, and Muhammad Abdullah Butt. "CRISPR-Cas mediated genome editing for disease resistance in crops: advances and challenges." *Pakistan Journal of Medical & Cardiological Review* 4, no. 3 (2025): 2677-2689.
 14. Riaz, Talha, Syed Tahaa Munawar, Ahmad Din, Muhammad Abdullah Butt, Sawera Hayat, Areej Azhar, Rabiya Riaz et al. "Microbiological safety, adulteration, and heavy metal-associated health risks in raw cow and buffalo milk from Punjab, Pakistan." *Food Science & Applied Microbiology Reports* 5, no. 1 (2026): 18-28.
 15. Riaz, Talha, Areej Azhar, Zhijun Xia, Aliza Batool, Xianjiang Ye, Burhan Khalid, Muhammad Moeid Khan et al. "Advances in plant-based functional foods: Emerging trends, nutritional potential, and health implications." *Food Science & Applied Microbiology Reports* 5, no. 1 (2026): 1-17.
 16. Naeem, Waleed, Muhammad Abdullah Butt, and Umer Javeid. "From entrepreneurship theory to startup execution: A simulation-based benchmark analysis of AI-enhanced venture decision systems in early-stage business performance." *Social Science Review Archives* 4, no. 1 (2026): 4065-4075.
 17. Khan Swati, Menahil, Musaffa Shahzadi, Muhammad Taha, Nida Shahzadi, and Muhammad Abdullah Butt. "The impact of orthodontic treatment on periodontal health: gingival recession, bone loss and patient-specific risk factors." *Research Consortium Archive* 4, no. 2 (2026): 1198-1213.
 18. Khan Swati, Menahil, Musaffa Shahzadi, Muhammad Taha, Nida Shahzadi, and Muhammad Abdullah Butt. "Silver diamine fluoride for caries arrest in pediatric and special needs populations: a decade of clinical evidence." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 693-704.
 19. Khurshid, Jamila, Zarlakhta Babar, Sajjad Ahmed, Muhammad Abdullah Butt, Umer Javeid, and Nida Khalil. "Beyond carbon footprints: unpacking the social dimensions of sustainability performance in emerging market firms." *Social Science Review Archives* 4, no. 1 (2026): 3386-3402.
 20. Butt, Muhammad Abdullah, Anam Ishaq, Rizwan Shukat, Qaisar Sohail, Muhammad Hamid Javed, Ambreen Saleem, Shazia Saeed, and Muhammad Mudassar Bashir. "Clinical Effects of Post-Exercise Low-Carbohydrate Recovery Diets on Bone Mineral Turnover, Hormonal Stability, and Lean Mass Preservation in Endurance-Trained Adults." *Research Consortium Archive* 4, no. 2 (2026): 1586-1599.
 21. Butt, Muhammad Abdullah, Feng Yiwen, and Umer Javeid. "Risk Governance Frameworks and Strategic Control Mechanisms for Managing Complexity in Global Business Operations." *Social Science Review Archives* 4, no. 2 (2026): 292-302.
 22. Butt, Muhammad Abdullah, Muhammad Umair Arshad, Ali Imran, and Muhammad Afzaal. "Ultrasonication-Enhanced Microbial Transglutaminase Crosslinking of Botanical and Foreign Protein for Sustainable High-Moisture Extruded Meat Analogue: A Comprehensive Multidimensional Characterization." *Genetics and Molecular Research* (2026).

23. Shah, Muhammad Saleem, and Muhammad Abdullah Butt. "Multi-Scale Computational Investigation of Plasma Instabilities in Next-Generation Fusion Reactors." *Spectrum of Engineering Sciences* 4, no. 3 (2026): 2257-2266.
24. Arif, Neha, Hafsa Shafiq, Moiza Noor, Taha Shahbaz, Aswad Khan, Hafsa Noor, Khalil Ahmed, Eman Farrukh, and Muhammad Abdullah Butt. "Artificial Intelligence in Cardiovascular Diagnostics: Integration of Laboratory Biomarkers, Medical Imaging, and Molecular Data." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 5665-5695.
25. Butt, Muhammad Abdullah, Wajid Hussain, Muhammad Junaid Anwar, Anam Ishaq, Luqman Khan, Muhammad Hammad Anwar, Talha Riaz et al. "AI-Guided Precision Fermentation for the Development of Personalized Functional Foods: A Food Technology Framework for Nutritional Optimization." *Research Consortium Archive* 4, no. 2 (2026): 2778-2795.
26. Awais, Muhammad, and Muhammad Abdullah Butt. "AI-DRIVEN ADAPTIVE PROTECTION SCHEMES FOR RESILIENT POWER SYSTEMS WITH HIGH PENETRATION OF DISTRIBUTED ENERGY RESOURCES." *Spectrum of Engineering Sciences* 4, no. 6 (2026): 1424-1434.
27. Butt, Muhammad Abdullah, Talha Riaz, Muhammad Abdullah Sadiq, Anam Ishaq, Ambreen Saleem, and Iza Almas. "AI-Assisted Nutrigenomic Modeling of Blueberry Anthocyanin–Gut Microbiome Interactions to Predict Butyrate Production and Insulin Sensitivity Improvement in Type II Diabetes." *Social Science Review Archives* 4, no. 2 (2026): 2159-2177.
28. Ullah, Saif, Muhammad Abdullah Butt, Qaisar Sohail, and Talha Riaz. "Multi-Omics Characterization of Fish Responses to Emerging Environmental Contaminants: Implications for Aquatic Toxicology and Sustainable Fisheries Management." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 5666-5685.
29. Butt, Muhammad Abdullah, Talha Riaz, Muhammad Abdullah Sadiq, Anam Ishaq, Ambreen Saleem, and Iza Almas. "Development of Polyphenol-Rich Pomegranate Peel Nutraceuticals for Glycemic Regulation, Insulin Sensitivity Improvement, and Oxidative Stress Reduction in Type II Diabetes Mellitus." *Journal for Current Sign* 4, no. 2 (2026): 2398-2413.
30. Ullah, Saif, Muhammad Abdullah Butt, Qaisar Sohail, Talha Riaz, and Shazia Saeed. "Toxicological Evaluation of Microplastic and Nanoplastic Exposure on Growth Performance, Oxidative Stress Biomarkers, and Histopathological Alterations in Cultured Fish Species." *Social Science Review Archives* 4, no. 2 (2026): 2178-2198.