Research

Agrawal S., and Kanani D. 2025. "Assessment of anthropometric and dietary iron intake status among young women in university settings." *World Nutrition*, *16*(2), June, 66–72. https://doi.org/10.26596/wn.202516266-72

Assessment of anthropometric and dietary iron intake status among young women in university settings

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Keywords: dietary Iron Intake, iron deficiency anemia, nutritional status, anthropometry, body composition, dietary practices, academic performance

https://doi.org/10.26596/wn.202516266-72

World Nutrition 2025;16(2):66-72

Background

Iron deficiency and poor nutritional status are prevalent among young women, especially in university settings, due largely to inadequate absorption of dietary iron, increased physiological demands, and lifestyle transitions. In some cases, dietary iron intake may be limited as well. Iron deficiency can have long-term health implications, including anemia, reduced academic performance, and, in young children, impaired physical and cognitive development.

Objective

This study aimed to assess the nutritional and dietary iron intake of women university students and to explore the relationship between current iron consumption and anthropometric measurements.

Methods

A cross-sectional study was conducted among 400 female university students aged 19–25 years in Surat, Gujarat, India. Data were collected using a structured questionnaire that included demographic details, and dietary iron intake in the past 24 hours. Anthropometric measurements were also taken. The data were analyzed using SPSS version 25, and Pearson correlation was employed to examine the relationship between dietary iron intake and anthropometric indicators.

Results

About half of the students (52%) had normal BMI, with 25% underweight and 23% overweight/obese. Most followed a vegetarian diet, frequently skipped meals, and had minimal physical activity. Energy, protein, iron, and vitamin C intakes were below recommendations, while fat intake was high and linked to central obesity. Iron intake inversely correlated with adiposity. Nutrient intake showed no significant association with academic performance. Knowledge and attitudes toward iron nutrition were generally poor.

Conclusions

Inadequate dietary iron intake was associated with low BMI and anemia, but also adiposity, indicating the need for targeted nutrition education and intervention programs. Regular screening and promotion of iron rich diets complemented with vitamin-C rich foods, especially in institutional settings, are essential to improve both iron levels and overall nutritional status in this vulnerable group.

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INTRODUCTION

Anemia remains a major global public health concern, particularly among women in developing countries. The World Health Organization (WHO 2025) estimated approximately 30.7% of women aged 15–49 years globally are affected by anemia. Among women, especially adolescents and young adults, iron deficiency anemia (IDA) is the most prevalent nutritional disorder, driven by inadequate intake, increased physiological demands, and poor iron absorption (Singh et al. 2015; Upadhye and Upadhye, 2017).

In India, nutritional challenges are exacerbated by early marriage, early pregnancy, gender-based dietary practices, and limited access to healthcare and to nutrition education. Young women experience increased iron requirements due to menstruation and growth, yet often lack dietary diversity. Studies report hemoglobin levels below 110 g/L in up to 70% of girls in low-income areas, rising to 80–90% under the WHO's 120 g/L threshold (Dungarwal, 2019).

Iron status is closely associated with overall nutritional health, particularly anthropometric indicators such as BMI, MUAC, WHR and body fat percentage. Under nutrition can impair iron metabolism, while excess body fat may reduce iron bioavailability through inflammation (Walny et al. 2021). University-aged women represent a unique demographic: they are transitioning into adulthood, often living away from home, making independent dietary choices, and dealing with academic stress. This life stage is critical for establishing lifelong nutrition-related behaviors. Moreover, poor iron and nutritional status during this phase may affect not only academic performance but also future reproductive health and chronic disease risk (Yanti et al. 2024; Edison et al. 2023).

Emerging evidence highlights links between low iron intake and altered body composition, especially increased central adiposity, due to iron's role in metabolism and energy regulation (Yanti et al. 2024; Dimas-Benedicto et al. 2024; Baruah and Gautam, 2023a). Despite several government-led programs such as the Weekly Iron and Folic Acid Supplementation, the National Nutritional Anemia Control Program, and Anemia Mukt Bharat, anemia remains widespread due to poor bioavailability of dietary iron, low intake of enhancers like vitamin C, modern cookware reducing iron leaching, and limited nutrition awareness (Khani Jeihooni et al. 2021; Bhatnagar and Padilla-Zakour, 2021).

In light of these persistent challenges, the present study aims to assess dietary iron intake and anthropometric status among university-aged women, explore correlations between iron intake and nutritional indicators, evaluate their knowledge, attitudes, and practices regarding iron and nutrition, and explore whether recent iron intake has a relationship with their academic performance.

METHODS

STUDY DESIGN AND PARTICIPANTS

A cross-sectional study was carried out between June 2024 and April 2025, involving 400 female students aged 19 to 25 years from Vanita Vishram Women's University in Surat, Gujarat, India. The sample size was determined using Slovin's formula with a 95% confidence level and a 5% margin of error (Singh and Masuku, 2014), yielding a minimum required sample of 375; however, 400 were included to reduce the risk of Type 2 statistical errors. A convenience sampling method was employed to select participants from the university due to its practicality and accessibility within the study's logistical and time constraints. Inclusion criteria comprised female university students aged 19–25 years who provided informed consent, while non-students and those outside the age range were excluded from the study.

DATA COLLECTION

Data were collected using a pre-tested, structured questionnaire through face-to-face interviews to ensure clarity and minimize response bias. Google forms were used to record responses efficiently. The questionnaire comprised four key sections:

1. *DEMOGRAPHIC PROFILE*: Included details such as age, marital status, family type, academic program, and level of physical activity. For assessing academic performance, participants were asked to provide their latest academic mark sheets, which contained their CGPA (Cumulative Grade Point Average) scores.

2. *ANTHROPOMETRIC MEASUREMENTS*: Standardized procedures based on WHO guidelines (2008) were followed. Height was measured using a wall-mounted stadiometer and weight with a calibrated digital scale. Body Mass Index (BMI) was calculated as weight (kg) divided by height squared (m^2) and classified according to WHO and Indian consensus standards (Table 1).

Table 1. Classification of body mass index (WHO, 2008)

Body Mass Index (kg/m²)	Classification
< 18.5	Underweight
18.5 – 24.9	Normal
25 – 29.9	Overweight
30 – 34.9	Obese Class I
35 – 39.9	Obese Class II
> 40	Obese Class III

3. *DIETARY ASSESSMENT*: A 24-hour dietary recall was used to record all foods and beverages consumed by participants in the previous day. The data were then converted to nutrient intakes (energy, macronutrients (carbohydrates, proteins, fats), and micronutrients (iron and vitamin C) using the Indian Food Composition Tables. The nutrient values were compared to the Recommended Dietary Allowances (RDA) -2024 to assess dietary adequacy and identify nutrient gaps (ICMR-NIN 2024).

4. *KNOWLEDGE, ATTITUDE, AND PRACTICE ASSESSMENT REGARDING DIETARY IRON INTAKE*:
Knowledge was measured using multiple-choice questions, with correct answers scored as '1' and incorrect as '0'. Attitude was assessed using a 5-point Liker scale ranging from "strongly agree" (5) to "strongly disagree" (1). Practice was evaluated with "yes/no" questions, scored as '1' for "yes" and '0' for "no".

QUESTIONNAIRE VALIDATION

The structured questionnaire was reviewed by subject matter experts and pre-tested on 30 respondents for clarity and reliability.

STATISTICAL ANALYSIS

Data were analyzed using Microsoft Excel and SPSS version 25. Descriptive statistics e.g. means, standard deviations, frequencies, and percentages were used for demographic and nutritional profiles. Bivariate Correlation was applied to assess relationships between nutrient intake, anthropometric indicators and academic performance. The significance of the correlation was assessed using p-values, with a threshold of $p < 0.05$ considered statistically significant.

RESULTS AND DISCUSSION

DEMOGRAPHIC PROFILE OF PARTICIPANTS

Table 2 shows that the majority of participants (85.3%) were aged 19-25 years, with most being unmarried (97%) and belonging to nuclear families (57.5%). This demographic distribution aligns with the study by (Abu-Baker et al. 2021), which noted that young women in similar age groups exhibit significant nutritional risks due to dietary habits and lifestyle choices. The predominance of nuclear families suggests that parental influence on dietary habits may be limited.

Table 2. Demographic profile of participants

Category	Sub category	Frequency (n=400)	Percentage %
Age (in years)	19-21	341	85
	22-24	52	13
	25 year	7	2
Marital status	Unmarried	388	97
	Married	10	2
	Divorced	2	1
Family type	Nuclear family	230	58
	Joint family	160	40
	Extended family	10	2

ANTHROPOMETRIC ASSESSMENT OF PARTICIPANTS

Table 3 shows that the mean body weight of the female university students was 53.6 ± 10.69 kg, and the average height was 157.28 ± 8.2 cm. These values suggest that most participants fall within the average range for adult Indian females. The mean waist circumference was 73.3 ± 10.5 cm, and the mean hip circumference was 92.2 ± 11.41cm suggesting potential concerns regarding central obesity. On average, participants fell within the normal weight and height range for adult Indian females. However, variability in waist and hip circumferences suggests differences in body fat distribution, possibly influenced by lifestyle factors such as diet and physical activity. Similar patterns were reported by Dimas-Benedicto et al. (2024), who highlighted the impact of poor dietary habits and sedentary behavior on metabolic health in young women.

Table 3. Anthropometric assessment of participants

S/N.	Anthropometric measurements	Mean ± SD
1	Weight (kg)	53.57 ± 10.69
2	Height (cm)	157.28 ± 8.23
4	Waist Circumference (cm)	73.31 ± 10.48
5	Hip Circumference (cm)	92.20 ± 11.41

BODY MASS INDEX (Kg/m²) CLASSIFICATION OF PARTICIPANTS

Figure 1 shows that majority of participants 208 (52%) fell within the normal BMI range, indicating an overall healthy weight status. However, a significant portion (25%) was underweight, which raises concerns about possible undernutrition, inadequate caloric intake, or lifestyle factors such as high academic stress or poor dietary habits—common issues among university students. Conversely, nearly a quarter (23%) of the participants were either overweight or obese, reflecting the rising trend of overweight or obesity among young adults in urban India. This transition may be attributed to increased consumption of calorie-dense foods, sedentary lifestyle, and low levels of physical activity. The coexistence of undernutrition and overnutrition in this population reflects the dual burden of malnutrition, a growing public health challenge in developing countries like India. These findings suggest the need for targeted nutritional interventions and health education programs to address both ends of the nutritional spectrum—particularly focusing on promoting balanced diets, physical activity, and regular health screenings.

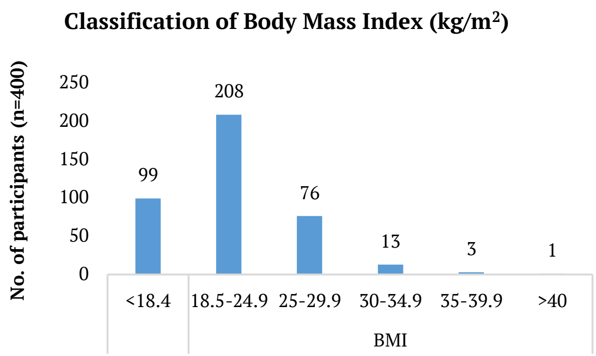

Figure 1. Body Mass Index (kg/m²) classification of participants

DIETARY PATTERN OF PARTICIPANTS

Table 4 provides data on some aspects of the dietary pattern of the participants. A significant proportion (77.5%) followed a vegetarian diet, reflecting common cultural or regional dietary preferences also contributing to low iron intake. Bhatnagar and Padilla-Zakour (2021) emphasized that plant-based diets in India often lack bioavailable iron. Over half of the students reported skipping meals, indicating a concerning trend that may impact nutritional intake and long-term health (Upadhye and Upadhye, 2017). Breakfast was the most commonly skipped meal, which can negatively affect metabolism, cognitive performance, and nutrient intake (Sámano et al. 2019). Skipping breakfast is often associated with irregular eating patterns and poor dietary quality (Fanelli et al. 2021). Nearly 70% of participants reported skipping meals at least once a week, with a significant number skipping more than three times. This irregularity in eating behavior can lead to nutritional deficiencies and may contribute to poor academic performance, fatigue, and weight-related issues (Pengpid and Peltzer, 2020).

Table 4. Dietary patterns of participants

Parameters	Category	Frequency (n=400)	Percentage (%)
Food habit	Vegetarian	310	77.5
	Non-Vegetarian	76	19
	Ovo-Vegetarian	13	3.25
	Vegan	1	0.25
Meal skipping	Yes	229	57.25
	No	171	42.75
Meal skipped the most	Breakfast	166	41.5
	Lunch	65	16.25
	Dinner	14	3.5
	None	155	38.75
Days Skipping Meals per Week	Once/Week	114	28.5
	Twice/Week	59	14.75
	Thrice/Week	31	7.75
	More than thrice	73	18.25
	None	123	30.75

PHYSICAL ACTIVITY OF PARTICIPANTS

Table 5 shows that 50.75% of participants reported light walking as their main form of physical activity, while 33.25 % participated in more than one physical activities. Upadhye and Upadhye (2017) found, that sedentary behavior was linked to poor nutritional and health outcomes. Regarding sleep patterns, a plurality (44.3%) of respondents went to bed between 10–11 PM, and 81.3% reported sleeping 6–8 hours per night. A combination of limited physical activity and suboptimal sleep habits may increase the risk of metabolic health issues, as supported by the findings of (Ranganath and Debata, 2015).

Table 5. Physical activity of participants

Parameter	Category	Frequency (n)	Percentage (%)
Type of Physical activity	Yoga	35	8.75
	Gym	12	3
	Light Walking	203	50.75
	Jogging	3	0.75
	Cycling	3	0.75
	None	11	2.75
	More than one from above	133	33.25
Usual bedtime	Before 10 pm	19	4.75
	Between 10-11pm	172	44.3
	Between 11-12 pm	148	37
	After 12 am	61	15.3
Sleeping hours per night	3-5 Hour	36	9
	6-8 Hour	325	81.3
	>8 Hour	39	9.75

NUTRIENT INTAKE OF PARTICIPANTS

Table 6 revealed significant nutrient deficiencies among participants, with average intakes of energy (1056.51 kcal), protein (30.98 g), carbohydrates (133.55 g), iron (6.48 mg), and vitamin C (50.02 mg) falling well below their respective RDAs. These findings align with previous studies, such as Saha and Biswas (2024b), who reported low energy intake among urban adult girls, and Walny et al. (2021), who highlighted the prevalence of low bioavailable iron in Indian diets. Although fat intake (49.13 g) exceeded the recommended 37 g, indicating an imbalance in macronutrient distribution, the low vitamin C intake may further impair iron absorption. These nutritional gaps underscore the need for targeted dietary education and interventions to address undernutrition and micronutrient deficiencies among young women.

Table 6. Nutrient intake of participants

Nutrients	Mean ± SD	RDA	Difference
Energy (kcal)	1056.51 ± 320.83	1660	-603.49
Protein (g)	30.98 ± 15.24	47	-16.018
Carbohydrate (g)	133.55 ± 70.71	270	-136.45
Fat (g)	49.13 ± 23.03	37	+12.13
Iron (mg)	6.48 ± 6.17	29	-22.53
Vitamin C (mg)	50.02 ± 36.42	65	-14.98

ACADEMIC PERFORMANCE OF PARTICIPANTS

Most participants scored between 6.0 and 7.99 CGPA, as shown in Table 7.

Table 7. Distribution of CGPA scores among participants

CGPA* Range	Frequency (n)	Percentage (%)
0.00 – 3.99	0	0.00
4.00 – 4.99	9	2.25
5.00 – 5.49	27	6.75
5.50 – 5.99	32	8.00
6.00 – 6.99	104	26.00
7.00 – 7.99	141	35.25
8.00 – 8.99	75	18.75

*Cumulative Grade Point Average

CORRELATION BETWEEN NUTRIENT INTAKE AND BODY COMPOSITION

Table 8 shows significant correlations between nutrient intake and body composition. Fat intake showed a significant positive correlation with waist and hip circumference Similar findings were reported by (Yuliani et al. 2020). Conversely, iron intake was inversely correlated with waist and hip circumference in line with the hypothesis that iron deficiency may contribute to abnormal fat distribution, as noted by (Yanti et al. 2024). Vitamin C showed weak but significant correlations with hip circumference and waist-hip ratio. The correlation analysis between nutrient intake and CGPA showed no significant associations.

Table 8. Correlation between nutrient intake, body composition and academic performance

Nutrients	Parameter	Weight (kg)	Height (cm)	BMI (kg/m2)	Waist (cm)	Hip (cm)	W-H ratio	CGPA*
Energy (Kcal)	Correlation coefficient	-0.046	-0.070	-0.002	0.046	0.043	0.066	0.039
	p value	0.361	0.164	0.968	0.363	0.394	0.187	0.442
Protein (gm)	Correlation coefficient	-0.031	-0.024	-0.002	-0.015	-0.029	0.031	0.029
	p value	0.537	0.638	0.962	0.772	0.560	0.540	0.565
Carbohydrate (gm)	Correlation coefficient	-0.037	-0.29	-0.007	-0.005	0.046	-0.030	0.058
	p value	0.457	0.561	0.884	0.928	0.355	0.547	0.246
Fat (gm)	Correlation coefficient	0.033	-0.059	0.071	**0.126**	**0.191**	0.032	-0.025
	p value	0.511	0.238	0.159	**0.012**	**0.000**	0.529	0.623
Iron (mg)	Correlation coefficient	-0.043	0.045	-0.033	**-0.106**	**-0.109**	-0.070	0.069
	p value	0.388	0.365	0.511	**0.034**	**0.029**	0.163	0.167
Vitamin C (mg)	Correlation coefficient	-0.013	-0.072	0.019	-0.014	**0.103**	**-0.102**	-0.007
	p value	0.794	0.148	0.705	0.776	**0.039**	**0.042**	0.887

*Cumulative Grade Point Average

KNOWLEDGE, ATTITUDE, PRACTICE ASSESSMENT REGARDING IRON INTAKE AND NUTRITION AWARENESS

KNOWLEDGE ASSESSMENT

Tables 9 and 10 indicate that most participants had poor knowledge regarding iron nutrition. These findings are consistent with those of Pareek (2015) and Noorani et al. (2023), who reported limited awareness among adolescent girls about dietary iron sources and anemia prevention. Similarly, Singh et al. (2015) identified significant gaps in nutritional education among young women. In contrast, Bhatnagar and Padilla-Zakour (2021) highlighted that educational interventions can substantially improve knowledge levels within target groups. The overall low knowledge levels observed in this study underscore the urgent need for structured educational initiatives to improve awareness of iron-rich foods, as well as factors affecting iron absorption.

Table 9. Knowledge assessment of respondents toward iron intake and nutrition (n = 400)

Question		Correct Response (n, %)	Incorrect Response (n, %)
1.	Symptoms of iron deficiency	150 (37.5)	250 (62.5)
2.	Rich sources of iron	92 (23.0)	308 (77.0)
3.	Vitamin which assists in iron absorption	250 (62.5)	150 (37.5)
4.	Functions of iron in the human body	253 (63.25)	147 (36.75)
5.	An iron-rich millet[1]	200 (50.0)	200 (50.0)
6.	Consequences of iron deficiency	293 (73.25)	107 (26.75)
7.	Bioavailable sources of iron	246 (61.5)	154 (38.5)
8.	Recommended daily iron intake for adult women	165 (41.25)	235 (58.75)
9.	Food combinations that inhibit iron absorption	217 (54.25)	183 (45.75)

[1]Iron-rich millet" refers to varieties such as finger millet or pearl millet, which are commonly consumed in some regions and known for their high iron content.

Table 10. Distribution of respondents by knowledge score category (n = 400)

Knowledge Category	Score Range	Frequency (n)	Percentage (%)
Poor Knowledge	0–4	243	60.75
Moderate Knowledge	5–7	148	37.0
Good Knowledge	8–10	9	2.25

Values are presented as frequency and percentage, n = 400 (%)

Attitude Assessment

Tables 11 and 12 indicate that the majority of participants (74.5%) held a neutral attitude towards iron consumption, while 22.75% showed a highly positive attitude. Only 2.75% exhibited a negative attitude. These results align with findings by Upadhye and Upadhye (2017), who observed that many young women maintained a neutral perspective on nutrition practices despite limited knowledge. Dungarwal (2019) emphasized that attitude alone does not necessarily lead to improved dietary behavior, as factors like affordability, taste preferences, and food availability play significant roles. The predominance of neutral attitudes in the present study suggests that although students are not resistant to iron intake, they may lack strong motivation or awareness of its urgency in their daily dietary practices.

Table 11. Attitude assessment of respondents toward iron intake and nutrition (n = 400)

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Iron is important for overall health and well-being.	265 (66.25)	112 (28)	21 (5.25)	1 (0.25)	1 (0.25)
2. Every girl should know about iron intake and its role in the body.	226 (56.5)	141 (35.25)	21 (5.25)	9 (2.25)	3 (0.75)
3. Taking vitamin C-rich foods with iron-rich foods is important for absorption.	160 (40)	169 (42.25)	52 (13)	14 (3.5)	5 (1.25)
4. Low iron levels are risky for girls in your age group.	161 (40.25)	170 (42.5)	45 (11.25)	16 (4)	8 (2)
5. [1]Thepla and curd make a good dietary combination.	144 (36)	180 (45)	53 (13.25)	13 (3.25)	10 (2.50)
6. A balanced diet can meet the body's iron requirements without supplements.	131 (32.75)	179 (44.75)	68 (17)	20 (5)	2 (0.50)
7. Supplements are a better source of iron than food.	89 (22.25)	133 (33.25)	103 (25.75)	54 (13.5)	21 (5.25)

[1]Thepla is a traditional Gujarati flatbread made from whole wheat flour, spices, and often fenugreek leaves mostly consumed on daily basis.

Table 12. Distribution of participants according to attitude scores towards iron intake (n = 400)

Attitude Category	Frequency (n)	Percentage (%)
Negative (Score 10–25)	11	2.75
Neutral (Score 26–40)	298	74.5
Highly Positive (Score 41–45)	91	22.75

ASSESSMENT OF PRACTICES REGARDING DIETARY IRON

Table 13 shows that 52.25% of participants exhibited moderate iron-related dietary practices, 24.75% demonstrated high practice scores, and 23% had low practice scores. These findings align with Kalasuramath et al. (2013), who reported that although adolescent girls possess some knowledge of iron-rich foods, consistent dietary improvements are often lacking. Additionally, Thankachan et al. (2008) highlighted that cultural dietary patterns, such as vegetarianism, contribute to inadequate iron intake among Indian women. This is supported by the high prevalence of vegetarianism (77.5%) and meal skipping (57%) observed in the present study. Furthermore, vitamin C intake was found to be below recommended levels, potentially impairing non-heme iron absorption, as noted by Saha and Biswas (2024b).

Table 13. Participant responses to iron-related dietary practices

Practice Question	Yes n (%)	No n (%)
Have you taken your breakfast regularly?	271 (67.75)	129 (32.25)
Do you take any iron supplements?	132 (33.00)	268 (67.00)
Do you consume at least 150 grams of fruits daily?	225 (56.25)	175 (43.75)
Do you engage in any physical activity?	244 (61.00)	156 (39.00)
Do you take green leafy vegetables regularly in your diet?	279 (69.75)	121 (30.25)
Do you usually include pulses and legumes in your daily diet?	249 (62.25)	151 (37.75)
Do you read food labels to check for iron content?	205 (51.25)	195 (48.75)
Do you often skip lunch due to a busy schedule?	243 (60.75)	157 (39.25)
Do you consume canteen or ready-to-eat food?	276 (69.00)	124 (31.00)
Do you consume dairy products daily?	299 (74.75)	101 (25.25)

CONCLUSION

This study highlights a dual burden of malnutrition among female university students aged 19–25 years, with significant undernutrition and overweight/obesity alongside central obesity risk. Predominantly vegetarian diets, frequent meal skipping, and low physical activity contributed to inadequate nutrient intakes, especially iron. Fat intake correlated with increased adiposity, while iron intake showed an inverse relationship with central fat. Nutrient intake was not significantly linked to academic performance, but poor knowledge and neutral attitudes toward iron nutrition may limit dietary improvements. Moderate conformity with practices beneficial to iron status indicate some engagement despite cultural and lifestyle barriers. Targeted, culturally sensitive nutrition education and lifestyle interventions may improve dietary habits, metabolic health, and academic outcomes in this group.

LIMITATIONS

This study's cross-sectional design and self-reported data limit causality and accuracy. Lack of biochemical tests and reliance on CGPA for academic performance are additional limitations. Future research should use longitudinal methods, biomarkers, and a wider range of variables.

AUTHOR CONTRIBUTIONS

SA designed and supervised the study. DK collected and analyzed data and contributed to manuscript writing. SA and DK performed statistical analysis, interpreted results, and wrote the manuscript. All authors approved the final version.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN SCIENTIFIC WRITING

ChatGTP and Quillbot were used for paraphrasing and refining content

ACKNOWLEDGEMENTS

The authors thank the University for its support and extend gratitude to all participants for their valuable contributions to this study.

FUNDING

None

Received: April 11, 2025; **Revised:** May 30, 2025; **Accepted:** June 24, 2025; **Published: June 30, 2025**

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