*West African Journal of Life Sciences. Available online at [http://www.wajls.com](http://www.wajls.com) ISSN (Print): 2992-5150. Volume 2; Issue 1:pages: 89-100*

***Full Length Research***

# Assessment of Body Mass Index and the Influence of Fasting Blood Glucose on Malaria-Recuperating Undergraduate Students

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**ABSTRACT**

The measurement of body mass index (BMI) and Fasting blood glucose (FBG) serve as a public health guide for assessing health status of humans. While the Body Mass Index measures individual's body fat, FBG estimates blood glucose level usually conducted after 8 to 10 hours abstinence from food and liquids (except water). The cross-sectional study evaluated the BMI and the FBS in apparently healthy undergraduate in a malaria endemic region in Nigeria. A sample size consisting of 113 females and 50 male students with a minimum of three years of enrollment in the Ambrose Alli University, Ekpoma were randomly recruited. The participants were informed of the purpose of the study and they submitted voluntarily. From each subject, fasting blood glucose was measured using glucometers, while BMI was calculated from height and weight measurement. Data was compiled, sorted and analysed using appropriate software. Results showed that 63.8% of participants had normal FBG levels, 34.4% were hypoglycemic, and 1.8% was pre-diabetic. Females exhibited slightly higher hypoglycemia rates of 20.25% and BMI with, 18.4% overweight and 7.3% obese scores compared to hypoglycemic rate of 14.11% in males with, 5% overweight and 0.65 case of obesity. A weak, non-significant positive correlation (r =0.121) was found between the BMI and FBG. The mean standard deviation values of FBG of malaria-asymptomatic, 73.50±14.52 and malaria-recuperating individuals 74.09±11.89 were close. Age-related trends indicated slightly elevated FBG among older participants 26 years and above (82.65±8.65), 22-25 years (78.81±5.72) and 18 -21years (81.57±8.10), possibly linked to declining insulin sensitivity. The findings highlight gender and age disparities in glucose regulation. A prevalence of 34.4% hypoglycemic state in an institution of higher learning can impact negatively on cognitive function and the overall well-being in affected students. Further research is recommended to investigate the relationship between clinical malaria infection and glucose metabolism.

*Received August 27, 2025*

*Received in Revised form, Sept. 15, 2025*

*Accepted Sept., 15, 2025*

*Available Online: Oct., 13, 2025*

*W. Afr. J. Life Sci. 2(1):89-100*

**Keywords**: hypoglycemia, glucometer, overweight, obesity, malaria-recuperating, liver

## INTRODUCTION

The Body Mass Index (BMI) is a way to assess the fat in an individual's body by a measure of weight in relation to their height (Asia and Arif, 2023). In adults BMI is typically grouped into underweight (<18.5), normal weight (18.5-24.9), overweight (25.0- 29.0), or obese (>30) (CDC, 2022). Study has proven that there is a significant correlation between BMI and factors for diabetogenesis such as insulin resistance (IR), first-phase insulin secretion (FPIS), second-phase insulin secretion (SPIS), and glucose effectiveness (GE) at a fixed fasting plasma glucose level (Lin et al., 2018). Compared to healthy weight, overweight or obesity is associated with many diseases such as: dyslipidemia (high level of triglyceride), high blood pressure, high or low cholesterol and type 2 diabetes, coronary heart disease, disease of the gallbladder, osteoarthritis, sleep apnea and breathing problems, various forms of cancers, lower quality of life, mental illness such as clinical depression, anxiety, and other mental disorders, body pain and difficulty with physical functioning (CDC, 2024). Thus, the measurement of BMI has been used as a guide to policies related to public health as it plays important role in assessing health problem in humans (Asia and Arif, 2023).

Glucose is an essential component derived from food that affects the functions of the body. It is the primary sugar in the bloodstream and serves as the major source of energy for the body. The body breaks down complex carbohydrate (food) into glucose, which enters the bloodstream, prompting the pancreas to produce insulin; a hormone that helps cells absorb glucose for energy (Jeanette, 2024). Fasting blood glucose (FBG) therefore, measures the amount of sugar in the blood after not eating for at least 8 hours (Charles, 2020). Normal fasting glucose levels range from 70–100 mg/d. Low glucose level in the blood impacts the functions of the central nervous system: the body's ability to regulate the glucose need in the body causing symptoms such as dizziness and confusion as well as intense hunger, arrhythmia (spike heartbeat) etc (Yale et al., 2018). Likewise, a sustained higher level of glucose in the blood can results in complication in the skin, eyes (vision loss), digestive disorder, nerves and damage to other organs (Mérida et al., 2021). Factors beyond food, such as stress, or physical activity and infections can also impact blood sugar levels (Jeanette, 2024).

Fasting plasma glucose levels are commonly elevated in cases of uncomplicated malaria, indicating the presence of insulin resistance. As the disease advances, the host's glucose production may fail to meet the combined metabolic needs of both the host and the parasite, increasing the likelihood of hypoglycemia (Binh et al., 1997). The *Plasmodium falciparum* infections can cause a rise in glucose production by 25% in adults (Patrick, 2013) but severe malaria often leads to dangerously low blood sugar levels in patients (Natalia, 2022). Besides, the developments of Plasmodium parasites at the liver stage depend on the availability of glucose (Meireles, et al. 2017). Hypoglycemia is a significant complication in severe *Plasmodium falciparum* malaria, particularly in children and pregnant women. While hyperglycemia is less frequently observed in critically ill malaria patients compared to hypoglycemia, it does occur and is thought to result from the disease itself or as a side effect of quinine treatment (Chianura et al., 2012).

Although, various factors disrupt glucose balance during malaria disease, including parasite metabolism, fever, hormonal shifts, inflammatory molecules like cytokines and chemokines, irregular immune responses, loss of appetite, wasting, and gastrointestinal complications (Mavondo et al., 2019); Severe malaria is associated with altered glucose regulation, manifesting as hyperglycemia, hypoglycemia, and hyperinsulinemia. Additionally, malaria treatments can negatively affect glucose metabolism, particularly in children, pregnant women, and those with no prior exposure to malaria (Mavondo et al., 2019).

This study was undertaken to assess the BMI and the FBS in apparently healthy undergraduate in Nigeria and also to check the relationship between FBS and individuals recovering from malaria fever.

## METHODOLOGY

### Area of Study

This study was conducted in the Faculty of Life Sciences, Ambrose Alli University, Ekpoma, Nigeria. Ambrose Alli University (AAU) is a state-owned university. Ekpoma is the administrative headquarters of the Esan West Local Government Area of Edo State. Ekpoma lies on the geographical coordinate of latitude 6°45′N 6°08′E. It has a population of over 290,000 people. It has an adult male population of over 90,000 and adult female population of over 80,000. It is politically divided into 10 wards and occupies a land mass of 502 $km^2$ (194 sq mi) (Giraffedata, 2024). The people are mainly of Esan tribe, and are predominantly academic and non-academic staff of Ambrose Alli University, owners of small scale medium enterprises (SME's), subsistence farmers and others which include civil service, trading, transportation and students of Ambrose Alli University. Besides, over 97% of the populations of students live outside the campus, within Ekpoma and neigbouring towns. The community enjoys a blend of traditional and orthodox medicine, with the presence of two general hospitals, some privately owned hospitals, and Government-owned health centres, and is also closely linked with Irrua Specialist Teaching Hospital, Irrua. There are other health facilities that offer services such as health education, immunization, family planning counseling, treatment of minor ailments and first aid, referrals, and anti-natal.

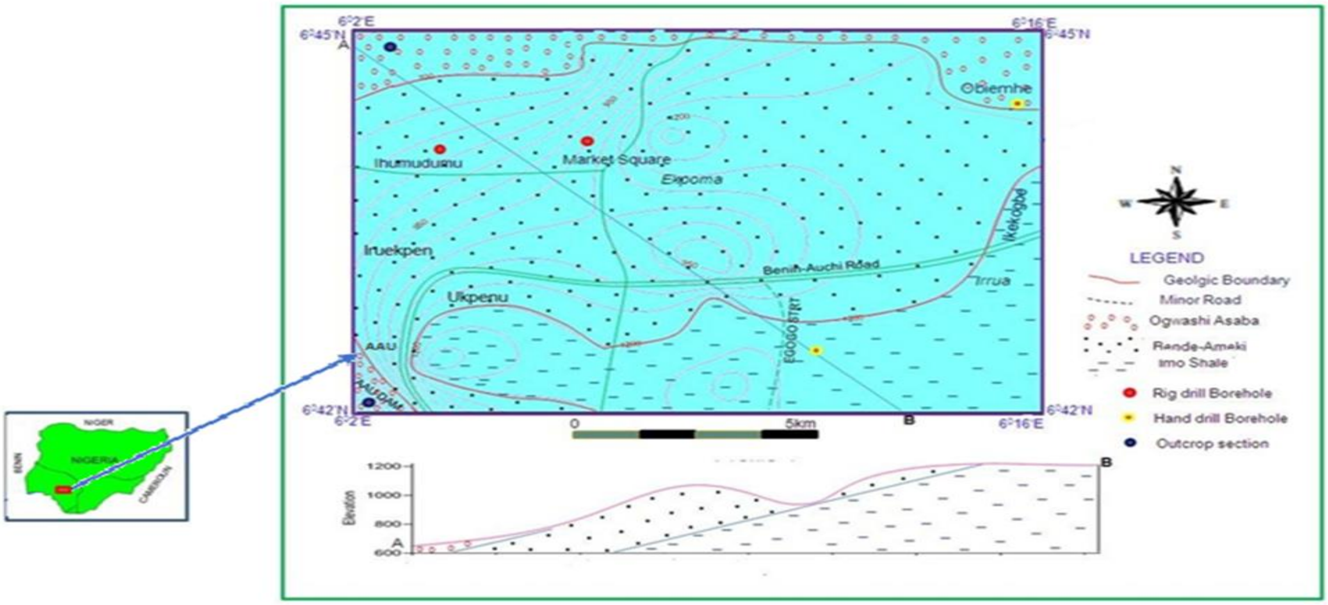


**Figure1: Map of the Study Area (Isaac and Samuel, 2021)**

**Study design**

**Equipment/Materials**

The materials used for this study were; Accu-Check active blood glucose meter, Accu-Check softclix lancing device, Accu-Check Softclix Lancets, Accu-Check active test strips, meter rule, Helmson bathroom weighing scale, Moko isopropyl alcohol, Cotton swab, gloves and sanitizer.

**Population of Study**

The population of the study was heterogeneous comprising males and females of different languages, cultural and religious backgrounds. They were all apparently healthy undergraduate, final year students in the faculty of Life Sciences, Ambrose Alli university, Ekpoma.

**Sample Size**

Since the population in the study area was above 1,000 people, the sample size was determined from the statistical formula;

$n = (Z^2.p\ (1-p)/d^2$

Where n = Minimum sample size

z = Level of confidence of 95% (standard value is 1.96)

p = Expected prevalence 11% (0.11)

d = Margin of error of 5% (0.05)

The prevalence in the study area was not known so a prevalence of 11% was taken based on a study by Sedodo et al. (2020).

Using the above formula, minimum sample size (n) = $1.96^2 \times 0.11(1-0.11)/0.05^2$ = 150.44

Minimum sample size was 150.44 so a total of 163 undergraduate students were recruited for the

study.

**Sampling procedure**

**Inclusion and Exclusion Criteria**
The participants were restricted only to the final year students, male and female who have spent a minimum of three years in studentship in the Ambrose Alli University, Ekpoma.

**Consent**
The participants submitted voluntarily for the study after being informed of the requirements and purpose of the study.

**Data collection methods**

**Structured questionnaires**
This was administered to every participant before the assessment of the blood glucose level. The questions were: age, sex, any medications, and state of diabetic and general health status and family history of known diseases.

**Body Mass Index (BMI) Evaluation**
The weight in kilogram of each participant was taken using the Helmson bathroom weighing scale. Each student was made to stand on the weighing scale with minimal clothing and accessories as possible, head facing forward and hands placed at the side. The obtained values were recorded with each subject's unique identifier (names and codes).

The height was measured using a portable stadiometer scale graduated in inches with the students standing on a flat surface bare foot, heads facing forward and without head accessories. The obtained values were recorded. The height which was measured in inches was converted to centimeter by multiplying the obtained height by 2.54 (since 1 inch=2.54cm) and then further converted to meter by dividing the calculated value by 100. The BMI was calculated using the formula; weight in kilogram divided by height in meter square.

The BMI of each subject was categorized into four (CDC, 2022).

BMI < 18.5: underweight

- 18.5-24.9: under healthy weight.
- 25.0-29.9: overweight.
- >30.0: obesity.

**Blood Glucose Evaluation**
Fasting blood glucose was measured after an overnight fast with the use of Accu-Check active blood glucose meter (glucometer). The subject’s thumb or index finger was cleaned with a wet cotton swab (dipped in isopropyl alcohol). A lancet was inserted into the Accu-Check softclix lancing device and the lancing device was primed by pressing the top inward. The Accu-Check active glucometer was turned on and then a test strip was gently placed in without bending; when a flashing drop symbol was displayed on the screen, the subject’s finger was picked by fixing the lancing device to the finger and then pressing the yellow button on the lancing device. The finger was massaged gently to facilitate blood flow and the blood added to the test strip. The result was displayed on the meter after about 5 seconds and was recorded.

All results were classified into normal, impaired or pre-diabetes and hypoglycemia but none was classified under diabetes or hyperglycemia.

FBG below 70 mg/dL: hypoglycemia.

70 mg/dL - 99 mg/dL: normal blood glucose and

100 mg/dL - 125 mg/dL was classified as impaired or prediabetes (Mathew et al., 2023)

**STATISTICAL ANALYSIS**

Raw data from the study was entered and organized in Microsoft Excel (MS Excel). Statistical analysis was conducted using both MS Excel and the Statistical Package for the Social Sciences (SPSS, version 27). T-test was used to determine the relationship between variables, with a significance level set at $p \leq 0.05$. Results were expressed as mean ± standard deviation and in tables and chart. A p-value of $\leq 0.05$ was considered statistically significant. $P \leq 0.05$.

**RESULTS**

Table 1 shows the distribution of the Body Mass Index of participants. Healthy weight had the highest value of 58.3%, followed by overweight, 23.31%., 10.43% of the population were underweight while 7.9% were obsessed.

**Table 1: Body Mass Index Distribution among Apparently Healthy Undergraduates**

| Variable | Underweight | Healthy Weight | Overweight | Obesity |
|---|---|---|---|---|
| Males | 11(7%) | 35 (21.5%) | 8 (5%) | 1(0.65) |
| Females | 6 (4%) | 60 (37%) | 30 (18.4%) | 12 (7.3%) |
| Total | 17(10.43%) | 95(58.28%) | 38 (23.31%) | 13 (7.98%) |

Table 2 shows the mean and standard deviation (Std) values for the fasting blood glucose profile of subjects. The mean±Std for hypoglycemia was 61.13±6.7; normal fasting blood glucose was 80.18±7.06 and prediabetes had a mean±Std value of 1.03±3.46. Of the overall population, 104(63.80%) had normal fasting blood glucose, 34.36% were hypoglycemic and 1.84% were pre-diabetic.

**Table 2: Fasting Blood Glucose Profile of subjects.**

| Variables | N=163 | Prevalence (%) | Mean ±Std. | F-Value | P-Value |
|---|---|---|---|---|---|
| Hypoglycemia | 56 | 34.36 | $61.13\pm6.7^{bc}$ | | |
| Normal FBG | 104 | 63.80 | $80.18\pm7.06^{ac}$ | 165.34 | 0.00 |
| Prediabetes | 3 | 1.84 | $1.03\pm3.46^{ab}$ | | |

*a, b* and *c* represent a statistically significant mean difference of 0.05 when comparison was made between groups.

Table 3 shows the mean±Std values for fasting blood glucose profiles of subjects based on gender. From the study population, 34.36% were hypoglycemic; 41.07% were males and 58.93% were females. An average of 63.80% individuals had normal fasting blood glucose: 25% were males while 75% were females. Only 1.84% participants were pre-diabetic with one male and two females representing 33.33% and 66.67%, respectively.

**Table 3: Gender Distribution of Fasting Blood Glucose Profile of subjects.**

| Variables | Hypoglycemia (n=56) Mean ± Std. | Normal FBG (n=104) Mean ± Std. | Prediabetes (n=3). Mean ± Std |
|---|---|---|---|
| Males | 60.65±7.47 | 78.81±7.43 | 1.07±0.00 |
| Females | 61.45±6.23 | 80.64±6.92 | 1.01±0.00 |

Table 4 shows the mean±Std values for age distribution of fasting blood glucose profile of participants. The ages were grouped into three (3) categories of 18-21 years, 22-25 years and 26 years - Above. For normal fasting blood glucose, age group 22-25 had the highest value of 36.20% of the overall population; followed by age group 18-21 with 17.18% while age group 26-Above had the least with 10.43%. Age group 22-25 had the highest number of hypoglycemic individuals with 29 occupying 17.79% of the study population followed by age group 26-Above with 14 individuals (8.59%) while age group 18-21 were 13 (7.98%).

Pre-diabetic individuals were 2 (1.23%) in the age group 26-Above and 1(0.61%) in age group 22-25. Age group 18-21 had no pre-diabetic individual.

**Table 4: Age Distribution of Fasting Blood Glucose Profile of Subjects**

| Age | Male | Female | Hypoglycemia (N=56) Mean ± Std. | Normal FBG (N=104) Mean ± Std. | Prediabetes (N=3) Mean ± Std. |
|---|---|---|---|---|---|
| 18-21 | 8 | 33 | 61.31±8.23 | 81.57±8.10 | - |
| 22-25 | 23 | 66 | 60.83±6.12 | 78.81±5.72 | 1.07±0.00 |
| >26 | 19 | 14 | 61.57±6.86 | 82.65±8.65 | 1.01±0.00 |

Table 5 shows the distribution of the body mass index among study population. Healthy weights were 95 (58.28%), followed by overweight 38(23.32%). Seventeen, 17(10.23%) were underweight while 13 students representing 7.98% were obsessed.

**Table 5: Body Mass Index Status of Subjects**

| Variable (sex) | Underweight | Healthy Weight | Overweight | Obesity |
|---|---|---|---|---|
| Male | 11(7%) | 35 (21.5%) | 8 (5%) | 1(0.65) |
| Female | 6 (4%) | 60 (37%) | 30 (18.4%) | 12 (7.3%) |
| Total | 17(10.43%) | 95(58.28%) | 38 (23.31%) | 13 (7.98%) |

Table 6 shows the correlation of fasting blood glucose and body mass index of subjects studied. FBG had a weak positive correlation (r) with BMI (0.121).

**Table 6: Correlation of FBG and BMI of subjects**

| Parameter | FBG (Correlation (r)) | P - Value |
|---|---|---|
| **BMI** | 0.121 | 0.124 |

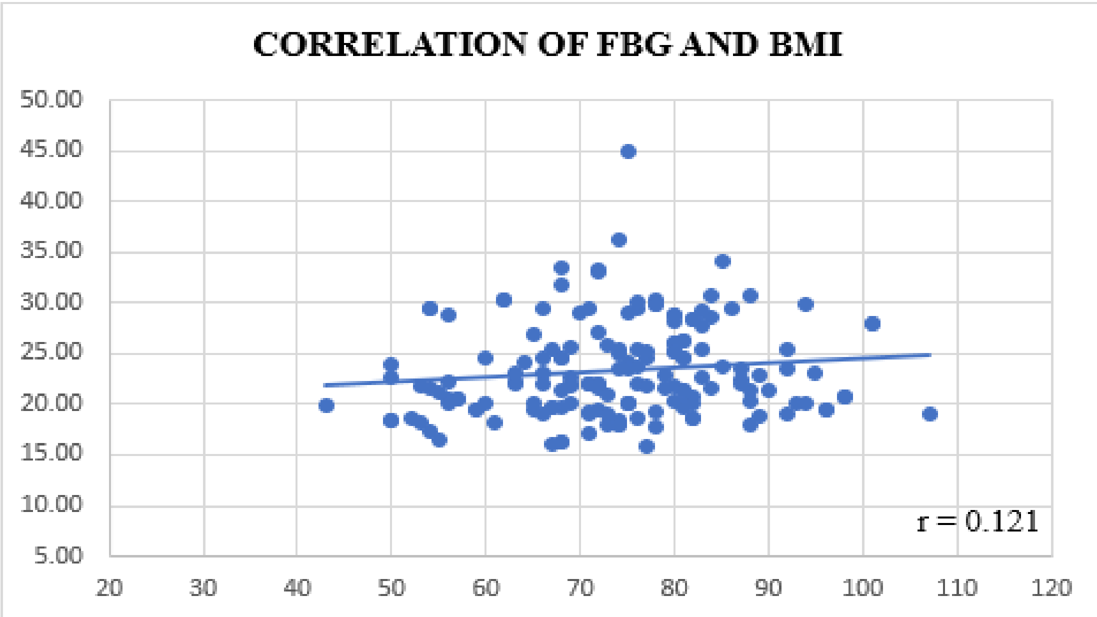


**Figure 2: Correlation of FBG and BMI of subjects. A correlation of 0.21 is positive but weak.**

Table 7 shows the mean value of fasting blood glucose in malaria asymptomatic and malaria-recuperating individuals in the study population. Malaria-recuperating individuals had a mean value of 73.5 and the mean value for malaria asymptomatic individuals was 74.09.

**Table 7: Mean Differences of FBG in Malaria Asymptomatic and Malaria-recuperating Individuals.**

| Variable | N=163 | Mean | P-Value |
|---|---|---|---|
| MRI | 10 | 73.50±14.52 | 0.88 |
| MAI | 153 | 74.09±11.89 | |

**MRI -** Malaria-recuperating Individuals **MAI -** Malaria asymptomatic Individuals

## DISCUSSION

A total of 163 individuals participated in the study; 113 (69%) females and 50 (31%) males all between the ages of 18 and 32.

The BMI scores were reflection of the financial strength and lifestyle of individual students, among other variables. Just a little more than half of the study populations (58.28%) were of healthy weight.

Underweight individuals were mostly males, 7% compared to 4% obtained from female students. Similarly, a majority of the overweight and obese individuals were as well females, 30 (18.4%) and 12 (7.3%) respectively. The higher BMI recorded in the female participants could be accounted to weight gain due to stress. Over 95% of the students studied leave in the neighboring villages, outside the campus where basic facilities for a good leaving and learning are not available. Such are stressors and they include epileptic power supply, absence of portable water, high cost of water (N200 per 25 liters), poorly ventilated hostel apartment, high cost of transportation (motor bike), and not excluding the vulnerability of the students to local aggressors. Studies have shown that girls (female undergraduates) tend to rest more after such strenuous periods leading to "creeping weight" due to the sensitization of hormone "ghrelin" that increases the hunger reflexes in both males and female which can be balanced by exercise in males but female tends to relax more and as such, there is the tendency of weight gain (Innocent et al., 2013). This study recorded more female students with higher BMI levels compared to males and it is similar to the report by Innocent et al., (2013) in a related study at Ibadan, Nigeria.

The present study also assessed the fasting blood glucose of subjects. From the results, 63.80% of the study population had a normal FBG. However, 34.36% of participants were hypoglycemic and the rest (1.84%) were pre-diabetic. Again, more females 58.93% than males 41.07% were hypoglycemic for several reasons such as differences in hormonal regulation as females have slower counter-regulatory hormone responses (e.g. reduced secretion of epinephrine and glucagon) during hypoglycemia compared to males implying that plasma glucose values would have to fall to a lower level in women before significant counter-regulatory hormone release occurs (Davis et al., 2000). Another reason could be due to hormonal fluctuations during menstrual cycle which can affect insulin sensitivity and result to hypoglycemia (Davis et al., 2000). This result is similar to that of Hossain et al., (2017) on fasting blood glucose level and its association with sex, body mass index and blood pressure in students of a public university in Bangladeshi.

A comparison based on age group showed that the mean value for hypoglycemia was slightly higher in subjects above 26 yrs compared to the younger groups. Normal Fasting blood glucose was also higher in the 26 yrs-Above group compared to the younger groups. This could be attributed to a natural decline in insulin sensitivity and impaired glucose regulation which expose older individuals to hypoglycemia during stress conditions or fasting (Innocent et al., 2013). This increase in FBG levels with age is consistent with the findings of (Innocent et al., 2013).

The relationship between BMI and FBG investigated using Pearson's correlation revealed a positive but weak non-significant ($p<0.05$) in consistence with report by Yuliawuri et al. (2024) whose study conducted in Jakarta. It was also in partial similarity to that of Hossain et al., 2017 whose study revealed a positive but significant relationship between BMI and FBG and that of Kaldera and Wickramatilake, (2023) which observed a statistically significant positive correlation between FPG and BMI.

The FBG in individuals recuperating from malaria and malaria asymptomatic subjects had closely related mean values and statistically non-significant.

**CONCLUSION**

This study reveals the complex factors influencing glucose regulation within a malaria-endemic population. It demonstrates how variables such as gender, age, BMI, and health status interact with fasting blood glucose levels, providing vital information for designing personalized health interventions. It highlights the importance of tracking glucose levels in specific populations, such as women, older individuals, and those with higher BMI, to help prevent future metabolic complications.

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