

# INVESTIGATING THE CORRELATION BETWEEN PACKED CELL VOLUME AND BODY MASS INDEX AMONG STUDENTS OF KADUNA STATE UNIVERSITY: A CROSS-SECTIONAL STUDY

\*<sup>1</sup>Solomon B., <sup>1</sup>Agbo B.O., <sup>1</sup>Genesis M.S., <sup>1</sup>Bawa D.G. & <sup>2</sup>Achara I.D.

<sup>1</sup>Department of Biological Sciences, Faculty of Life Sciences, College of Computing, Engineering and Science, Kaduna State University, Kaduna, Nigeria

<sup>2</sup>Barau Dikko Teaching Hospital, Kaduna, Kaduna State, Nigeria

\*Corresponding Author Email Address: [bitrus.solomon@kasu.edu.ng](mailto:bitrus.solomon@kasu.edu.ng)

## ABSTRACT

Packed cell volume (PCV) is an important haematological parameter that reflects the oxygen-carrying capacity of blood. At the same time, body mass index (BMI) is widely used to assess nutritional status and body weight. Both indicators are essential for evaluating overall health, particularly among young adults who may face nutritional challenges, infections, and lifestyle-related risks. This study investigated the relationship between PCV and BMI among undergraduate students of Kaduna State University (KASU) main campus. The study adopted a cross-sectional design involving 100 apparently healthy students (50 males and 50 females). PCV was determined using the microhaematocrit method, while BMI was calculated from measured height and weight. Data were analysed using SPSS version 25, and Pearson correlation was used to assess the relationship between BMI and PCV at  $p \leq 0.05$ . Low PCV was observed in 31.0% of participants, indicating a substantial proportion at risk of anemia, with similar distribution between males (32.0%) and females (30.0%). Regarding BMI, 61.0% of students were of normal weight, 27.0% were underweight, and 12.0% were overweight or obese. A weak but statistically significant positive correlation was observed between BMI and PCV in the overall sample ( $r = 0.233$ ,  $p = 0.019$ ), whereas sex-specific analysis showed no significant relationship. The study concludes that although BMI is associated with PCV, the relationship is weak and inconsistent across subgroups, indicating that BMI alone is not a reliable predictor of haematological status. Therefore, routine haematological screening in addition to anthropometric assessment is recommended for early detection of blood-related disorders among students.

**Keywords:** Body mass index (BMI); Packed cell volume (PCV); Anaemia; Nutritional status; University students; Blood health

## INTRODUCTION

Packed cell volume (PCV), also known as haematocrit, represents the proportion of red blood cells in total blood volume and is a key indicator of haematological health due to its direct relationship with the blood's oxygen-carrying capacity (Abdulqader, 2023). Globally, PCV is widely used in clinical and epidemiological practice to assess anemia, dehydration, and polycythemia, as deviations from normal values often reflect underlying physiological or pathological conditions (Olaifa et al., 2022; World Health Organization [WHO], 2023). Furthermore, PCV is influenced by several factors, including hydration status, altitude, nutritional status, and chronic diseases, making it a sensitive yet non-specific marker of overall health (Bello et al., 2024; Adebayo et al., 2023).

In parallel, body mass index (BMI), calculated from weight and height, is a widely used anthropometric index for classifying individuals as underweight, normal weight, overweight, or obese (Held et al., 2022). At the global level, the increasing prevalence of overweight and obesity has become a major public health concern, prompting growing interest in how BMI relates to physiological and clinical parameters, including haematological indices such as PCV (WHO, 2021; NCD Risk Factor Collaboration, 2023). Evidence from different regions suggests that BMI may influence red cell indices through mechanisms linked to nutrition, inflammation, and metabolic changes.

Empirical studies have examined the relationship between body mass index (BMI) and packed cell volume (PCV), with inconsistent findings across populations. Some studies have reported a positive association, indicating that higher BMI is linked with increased PCV (Abdulqader, 2023; Gupta et al., 2020). However, other studies, particularly in high-income countries, have found weak or non-significant relationships, suggesting that the association may be influenced by lifestyle and underlying health conditions (Ford et al., 2019; Ugwuja et al., 2015).

In low- and middle-income countries, particularly in sub-Saharan Africa, this relationship is further complicated by the coexistence of infectious diseases and nutritional transitions. Conditions such as malaria and other infections are known to reduce PCV, while increasing rates of overweight and obesity may influence haematological parameters in the opposite direction (Ibrahim et al., 2023; Adebayo et al., 2023).

In Nigeria, available evidence suggests that the relationship between BMI and PCV is generally weak and influenced by factors such as sex, infection status, and nutritional conditions (Okeke et al., 2024; Yusuf et al., 2024). Among university students, irregular dietary habits, stress, and limited engagement in routine health screening may further affect both BMI and PCV (Ciroma et al., 2019; Obeagu et al., 2022).

Despite these findings, there remains limited data on the integration of anthropometric and haematological parameters among university students in Nigeria. Therefore, this study aims to assess the relationship between BMI and PCV in this population, providing context-specific evidence in a setting characterized by both infectious and lifestyle-related risk factors.

## MATERIALS AND METHODS

### Study Area

This study was conducted at Kaduna State University (KASU), located in Kaduna State, Nigeria. The University comprises several

faculties with a diverse population of undergraduate and postgraduate students from different socio-economic backgrounds.

### Study Design

This study employed a cross-sectional descriptive design to assess the relationship between packed cell volume (PCV) and body mass index (BMI) among students.

### Study Population

The study population comprised undergraduate and postgraduate students of the Kaduna State University main campus.

Students who provided informed written consent were included in the study. Those who reported recent illness or were on medications known to affect haematological parameters were excluded.

### Ethical Consideration and Recruitment

Ethical approval for the study was obtained from the Kaduna State University Health Unit prior to the commencement of data collection. Participants were recruited from different faculties following sensitization on the study objectives.

### Sample Size Determination

The sample size for this study was determined using the formula for cross-sectional studies:

$$n = Z^2pq / d^2$$

where  $n$  = required sample size,  $Z$  = standard normal deviate at 95% confidence level (1.96),  $p$  = estimated prevalence (assumed to be 50% due to lack of prior data),  $q = 1 - p$ , and  $d$  = margin of error (0.05).

The calculated minimum sample size was 384 based on standard formulae for cross-sectional studies. However, due to feasibility constraints, a total of 100 participants were included. While this is lower than the calculated sample size, it is consistent with similar exploratory studies. It is considered adequate for detecting preliminary associations between variables, although with limited statistical power.

### Sampling Technique

A simple random sampling technique was used to select participants from a pool of consenting students across different faculties. Volunteers were first sensitized about the study, after which eligible participants were randomly selected to reduce selection bias.

### Inclusion and Exclusion Criteria

Students of Kaduna State University who provided informed written consent and were apparently healthy at the time of the study were included. In contrast, Students with a known history of recent illness or those on medications known to affect haematological parameters were excluded.

### Data Collection

Data were collected between November and December 2025, using a structured data collection form. Information obtained included demographic characteristics such as age and sex. Anthropometric measurements (weight and height) were taken using standard procedures, and body mass index (BMI) was calculated. Packed cell volume (PCV) was determined using the microhaematocrit method.

All measurements were carried out by trained personnel following standard laboratory procedures.

All participants were adequately informed about the study, and both verbal and written consent were obtained prior to data collection. Demographic information, including age and sex, was recorded using a structured data collection form.

Anthropometric measurements were conducted using standard procedures. Body weight was measured using a calibrated weighing scale, with participants wearing light clothing and standing upright. Height was measured using a stadiometer, with participants standing barefoot and erect. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in metres ( $\text{kg}/\text{m}^2$ ), in accordance with established guidelines (World Health Organization [WHO], 2022).

Packed cell volume (PCV) was determined using the microhaematocrit method. The fingertip was cleaned with 70% alcohol, and a sterile lancet was used to obtain capillary blood. Blood samples were collected into heparinized capillary tubes, sealed at one end with plasticine, and centrifuged in a microhaematocrit centrifuge at 11,000 rpm for 5 minutes. The PCV was then read using a microhaematocrit reader and recorded as a percentage (Cheesbrough, 2023). All sharps and biological waste were disposed of in accordance with standard biomedical waste management guidelines (WHO, 2020).

PCV values were classified based on standard haematological reference ranges: low (<40% males, <36% females), normal (40–54% males, 36–46% females), and high (>54% males, >46% females), in line with established clinical hematology guidelines (Bain et al., 2021; Hoffbrand & Moss, 2023).

### Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0. Descriptive statistics were computed for all variables, and Pearson correlation analysis was used to assess the relationship between body mass index (BMI) and packed cell volume (PCV). Normality of continuous variables was assessed using the Shapiro–Wilk test, complemented by visual inspection of histograms and Q–Q plots, to determine the appropriateness of parametric

## RESULTS

The study included 100 participants with equal representation of males and females. Age data were available for 57% of participants. Among these, the majority (93.0%) were aged 21–25 years, indicating that the study population was largely composed of young adults. A substantial proportion of participants (43%) did not report their age and were excluded from age-based analyses, potentially limiting the interpretation of age-related findings (Table 1).

**Table 1:** Sex and Age Distribution of Participants (n = 57)

Age group (years)	Male N (%)	Female N (%)	Total N (%)
15–20	0 (0.0)	2 (3.5)	2 (3.5)
21–25	11 (19.3)	42 (73.7)	53 (93.0)
26–30	0 (0.0)	1 (1.8)	1 (1.8)
31+	1 (1.8)	0 (0.0)	1 (1.8)
<b>Total</b>	<b>12 (21.1)</b>	<b>45 (78.9)</b>	<b>57 (100.0)</b>

Age data were available for 57 participants. A total of 43 participants did not report their age and were excluded from age-based analysis.

Most participants were not on medication, suggesting minimal external influence on PCV. However, a slightly higher proportion of females were on medication. Among females, 16% were menstruating, which is important since menstruation may temporarily reduce PCV (Table 2, A & B). Menstruating participants were not excluded from the study because menstruation represents a normal physiological process. However, menstruation status was documented and considered a potential confounding factor in the interpretation of PCV values among female participants.

**Table 2: Medication and Menstruation Status**

**A. Medication Status**

Sex	No N (%)	Yes N (%)	Total
Male	47 (94.0)	3 (6.0)	50
Female	44 (88.0)	6 (12.0)	50

**B. Menstruation Status (Females Only)**

Status	Frequency N (%)
No	42 (84.0)
Yes	8 (16.0)
<b>Total</b>	<b>50 (100.0)</b>

Medication use and menstruation status were assessed as part of participants' baseline characteristics to document potential physiological factors that may influence body weight and related health indicators. However, these variables were treated as descriptive covariates rather than as primary variables of interest for BMI outcomes, as they are typically considered potential confounders in anthropometric and reproductive health studies (Yu et al., 2025; Verfürden et al., 2025; Itoi et al., 2026). Males had a higher mean PCV compared to females. Females showed greater variability, with an extremely low value (14%), suggesting possible severe anemia in at least one participant (Table 3)

**Table 3: Descriptive Statistics of PCV (%)**

PCV = Packed Cell Volume; SD = Standard Deviation.

Group	r-value	p-value	Decision (p< 0.05)
All participants	0.233	0.019	Significant
Males	0.204	0.154	Not significant
Females	0.214	0.135	Not significant

About one-third (31%) of participants had low PCV. The proportion was similar in both sexes, indicating that reduced PCV is a shared issue among students (Table 4)

**Table 4: PCV Classification by Sex**

PCV Status	Male (%)	Female (%)	Total (%)
Low PCV	16 (32.0)	15 (30.0)	31 (31.0)
Non-Low PCV	34 (68.0)	35 (70.0)	69 (69.0)
<b>Total</b>	<b>50 (100)</b>	<b>50 (100)</b>	<b>100 (100)</b>

Table 4 shows the distribution of PCV status by sex. Low PCV was slightly more prevalent among males 16 (32.0%) compared to females 15 (30.0%). The majority of participants in both males 34 (68.0%) and females 35 (70.0%) had non-low PCV values. Overall, 31 (31.0%) of the study population had low PCV, indicating a notable proportion of students at risk of anaemia, with no substantial difference observed between sexes.

Most participants had normal BMI 61 (61%). However, underweight was relatively high 27 (27%), especially among females, while overweight/obesity was less common (Table 5).

**Table 5: BMI Classification based on WHO Standard.**

BMI Category	Male (%)	Female (%)	Total (%)
Underweight (<18.5 kg/m <sup>2</sup> )	11 (22.0)	16 (32.0)	27 (27.0)
Normal (18.5–24.9 kg/m <sup>2</sup> )	31 (62.0)	30 (60.0)	61 (61.0)
Overweight (25.0–29.9 kg/m <sup>2</sup> )	7 (14.0)	2 (4.0)	9 (9.0)
Obese (≥30.0 kg/m <sup>2</sup> )	1 (2.0)	2 (4.0)	3 (3.0)
<b>Total</b>	<b>50 (100.0)</b>	<b>50 (100.0)</b>	<b>100 (100.0)</b>

The majority of participants fell within the normal BMI category, accounting for **61 (61.0%)** of the total population, with similar proportions observed among males **31 (62.0%)** and females **30 (60.0%)**. A notable proportion of respondents were underweight, comprising **27 (27.0%)**, with a higher prevalence among females **16 (32.0%)** compared to males **11 (22.0%)**. Overweight individuals constituted **9 (9.0%)** of the study population, occurring more frequently in males **7 (14.0%)** than females **2 (4.0%)**. Obesity was relatively uncommon, observed in only **3 (3.0%)** of participants, with slightly higher prevalence among females **2 (4.0%)** than males **1 (2.0%)**.

**Table 6** presents the Pearson correlation analysis between body mass index (BMI) and packed cell volume (PCV) among the study participants, including sex-specific comparisons.

**Table 6: Pearson Correlation between BMI and PCV**

Sex	N	Mean (%)	PCV SD	Minimum	Maximum
Male	50	42.66	5.02	30.00	54.00
Female	50	39.22	7.77	14.00	56.00

A weak positive correlation was observed between BMI and PCV among all participants ( $r = 0.233$ ,  $p = 0.019$ ). However, the correlation was not statistically significant among males ( $r = 0.204$ ,  $p = 0.154$ ) and females ( $r = 0.214$ ,  $p = 0.135$ ).

## DISCUSSION

Packed cell volume (PCV) is a key haematological indicator of oxygen-carrying capacity, while body mass index (BMI) is a widely used anthropometric index for categorizing body weight status. This study evaluated the relationship between BMI and PCV among university students, providing insight into the interaction between body composition and haematological health in young adults. Although BMI is commonly used as a proxy for nutritional status, PCV is influenced by a wider range of physiological and environmental factors, including nutritional intake, infection status, hydration, medication use, and reproductive physiology.

In this study, males exhibited higher mean PCV (42.66%) than females (39.22%), with females showing greater variability and a markedly lower minimum value (14%). This sex-based difference aligns with established physiological patterns, where females typically have lower PCV due to menstrual blood loss and hormonal influences on erythropoiesis. Studies among young adults have consistently demonstrated significantly higher haemoglobin and PCV levels in males compared to females, largely attributed to androgen stimulation of erythropoiesis and periodic menstrual losses in females (e.g., WHO, 2023; Ugwuja et al., 2015; Ford et al., 2019). In the present study, the inclusion of menstruating participants (16% of females) may have further contributed to the observed reduction and variability in female PCV values, supporting the role of menstruation as an important physiological confounder in haematological assessment.

A notable finding was that 31.0% of participants had low PCV, indicating a substantial burden of possible anaemia among apparently healthy young adults. This prevalence is comparable to findings from similar studies among university populations in Nigeria and other sub-Saharan African settings, where anaemia prevalence ranges from moderate to high levels depending on dietary patterns and infection burden (Ibrahim et al., 2023; Musa et al., 2022). The presence of low PCV across both sexes suggests that the burden is population-wide rather than sex-specific, and may reflect underlying factors such as iron deficiency, subclinical infections (particularly malaria), or poor dietary intake, all of which have been widely documented in similar populations (Okunbor et al., 2024; WHO, 2023).

With respect to BMI, most participants (61.0%) were within the normal weight range, while 27.0% were underweight and 12.0% were overweight or obese. This pattern reflects a dual burden of malnutrition, a phenomenon increasingly reported among young adult populations in developing countries, where undernutrition and emerging over nutrition coexist within the same demographic group (Adeloye et al., 2021; NCD Risk Factor Collaboration, 2023). The relatively high proportion of underweight individuals, particularly among females, may be associated with irregular dietary habits, academic stress, and socioeconomic constraints commonly observed in university environments (Ciroma et al., 2019; Obeagu et al., 2022).

The principal finding of this study was a weak but statistically significant positive correlation between BMI and PCV in the overall population ( $r = 0.233$ ,  $p = 0.019$ ), suggesting that individuals with higher BMI tend to have slightly higher PCV values. This weak association is consistent with several studies reporting either weak

or inconsistent relationships between anthropometric indices and haematological parameters in young adults. For example, studies have shown that while improved nutritional status may support erythropoiesis, BMI alone is not a strong independent predictor of haematological health due to the influence of multiple confounding biological and environmental factors (Gupta et al., 2020; Martins et al., 2023; Al-Hassan et al., 2023).

However, when stratified by sex, the relationship between BMI and PCV was not statistically significant in males ( $p = 0.154$ ) or females ( $p = 0.135$ ). This suggests that the overall significant association may be influenced by combined sample effects rather than true sex-specific biological relationships. Similar findings have been reported in other studies where associations between BMI and haematological indices diminished or became non-significant after stratification or adjustment for confounders (Ugwuja et al., 2015; Okeke et al., 2024; Yusuf et al., 2024). This reinforces the conclusion that BMI alone is insufficient as an independent predictor of PCV in homogeneous subgroups.

The weak association observed indicates that PCV is influenced by multiple interacting factors beyond body mass. These include nutritional iron status, infectious diseases such as malaria, hydration levels, medication use, and physiological conditions such as menstruation. In malaria-endemic regions such as Nigeria, repeated or subclinical infections can significantly reduce PCV through haemolysis and impaired erythropoiesis (Musa et al., 2022; WHO, 2023). In this study, the presence of menstruating participants and individuals on medication further supports the likelihood of multiple non-BMI determinants influencing PCV variation.

The university student context may also contribute significantly to these findings. Previous studies have shown that university students often exhibit irregular dietary intake, limited access to routine medical screening, and lifestyle-related stressors that can influence both anthropometric and haematological outcomes (Ciroma et al., 2019; Obeagu et al., 2022). These factors may partly explain why some individuals with normal BMI still exhibited low PCV, while others with lower BMI maintained normal haematological values.

Overall, this study demonstrates that although a statistically significant relationship exists between BMI and PCV at the population level, the association is weak and not consistent across sex-specific analyses. This finding is consistent with the broader literature indicating that anthropometric indices alone are insufficient predictors of haematological status in young adults. Therefore, PCV assessment should be interpreted in conjunction with clinical, nutritional, and environmental factors for a more accurate evaluation of health status.

## Conclusion

This study demonstrated a weak but statistically significant relationship between body mass index (BMI) and packed cell volume (PCV) among students of Kaduna State University. However, this association was not statistically significant when analysed separately by sex, indicating that BMI alone is not a strong independent predictor of PCV in this population.

A notable proportion of participants exhibited low PCV (31.0%), suggesting a potential burden of reduced haematological status among apparently healthy young adults. Variations in PCV across BMI categories further indicate that body composition may play a role, although this effect appears to be influenced by multiple physiological and environmental factors.

Overall, the findings highlight that PCV is a multifactorial haematological parameter influenced not only by body mass index but also by factors such as nutritional status, menstrual physiology, and possible subclinical infections. Therefore, BMI should not be used in isolation for interpreting haematological health.

The study underscores the importance of integrating anthropometric and haematological assessments in routine health evaluation of young adults. Further research involving larger and more diverse populations, with control for key clinical confounders, is recommended to better clarify the relationship between BMI and haematological parameters.

## REFERENCES

- Abdulqader, B.K. (2023) 'Packed cell volume (PCV) and its relation to obesity, gender and smoking status', *Acta Medica Marisensis*, 69(3), pp. 317–322.
- Adebayo, O.O., Salami, A.T. and Lawal, M.O., (2023). Nutritional transition and its impact on health indices in sub-Saharan Africa. *African Journal of Biomedical Research*, 26(2), pp.145–152.
- Adeloye, D. *et al.*, (2021). Estimating the prevalence of overweight and obesity in Nigeria. *Annals of Medicine*, 53(1), pp.495–507.
- Al-Hassan, H., Al-Mutairi, S. and Al-Qahtani, A., (2023). Association of BMI with PCV. *BMC Hematology*, 23, pp.112–121.
- Bain, B. J., Bates, I., Laffan, M. A., & Lewis, S. M. (2021). *Dacie and Lewis practical haematology* (13th ed.). Elsevier.
- Bello, A.M., Yusuf, I. and Sani, M., (2024). Haematological variations among adults in Northern Nigeria. *African Journal of Laboratory Medicine*, 13(1), pp.1–7.
- Cheesbrough, M., (2023). *District Laboratory Practice in Tropical Countries*. Cambridge: Cambridge University Press.
- Ciroma, F.L. *et al.*, (2019). Haematological parameters and obesity in Kaduna State. *Sub-Saharan African Journal of Medicine*, 6(1), pp.19–24.
- Edeki, T., Ogene, P. and Ebong, V., (2024). BMI and anaemia among female students. *Nigerian Journal of Haematology*, 14(1), pp.44–52.
- Ford, E.S. *et al.*, (2019). Obesity and hematological parameters. *American Journal of Clinical Nutrition*, 110(3), pp.567–575.
- Gupta, R., Sharma, P. and Singh, A., (2020). BMI and hematological parameters. *Indian Journal of Physiology and Pharmacology*, 64(2), pp.123–129.
- Held, C. *et al.*, (2022). Body mass index and health outcomes. *The Lancet Public Health*, 7(2), pp.e123–e131.
- Hoffbrand, A. V., & Moss, P. A. H. (2023). *Essential haematology* (8th ed.). Wiley-Blackwell.
- Ibrahim, A.O., Aina, O.O. and Musa, Y., (2023). Malaria and haematological parameters. *Journal of Parasitology Research*, 2023, p.665423.
- Itoi, S., Sampei, M., Tatsumi, T., Ishida, R., Izumi, G., Osuga, Y., Koga, K., Narumi, S., & Morisaki, N. (2026). Within-individual changes in BMI and menstrual irregularity: A cohort study using real-world data. *BMC Women's Health*, 26(1), 124. <https://doi.org/10.1186/s12905-026-04308-2>
- Jeong, S.K., Nam, H.S. and Son, M.H., (2022). BMI and hematological indices. *European Journal of Clinical Nutrition*, 76(5), pp.735–742.
- Liu, Y., Zhang, L. and Huang, J., (2022). BMI and PCV among students. *Asia-Pacific Journal of Clinical Nutrition*, 31(4), pp.678–686.
- Martins, R., Silva, F. and Costa, A., (2023). BMI and PCV in students. *Revista Brasileira de Hematologia e Hemoterapia*, 45(1), e2023005.
- Musa, A., Abdullahi, I. and Suleiman, M., (2022). BMI, PCV and malaria. *Nigerian Journal of Physiological Sciences*, 37(2), pp.101–109.
- Non-Communicable Disease Risk Factor Collaboration (NCD-RisC) (2023) 'Global BMI trends', *The Lancet Global Health*, 11(5), pp. e678–e689.
- Obeagu, E.I., Odo, M. and Nwagbara, C.I., (2022). Obesity and PCV. *Nigerian Journal of Health Sciences*, 10(2), pp.74–79.
- Okeke, C., Nwankwo, J. and Ibrahim, A., (2024). BMI and red cell indices. *Sub-Saharan African Journal of Medicine*, 11(1), pp.23–31.
- Okunbor, J.I. *et al.*, (2024). BMI and blood indices in Nigeria. *Nigerian Journal of Medical Sciences*, 33(1), pp.21–29.
- Olaifa, F.E., Adeyemi, A.S. and Lawal, T.A., (2022). Clinical relevance of PCV. *Nigerian Journal of Clinical Practice*, 25(4), pp.567–572.
- Rahman, M.M. *et al.*, (2021). Influences on hematological indices. *BMC Public Health*, 21, p.1456.
- Setia, M.S., (2016). Methodology series module 3: Cross-sectional studies. *Indian Journal of Dermatology*, 61(3), pp.261–264.
- Ugwuja, E.I. *et al.*, (2015). BMI and haemoglobin. *Annals of Medical and Health Sciences Research*, 5(3), pp.180–185.
- Verfürden, M. L., *et al.* (2025). Association between weight change and reproductive outcomes in women: A cohort analysis. *Human Reproduction*, 40(9), 1753–1765. <https://doi.org/10.1093/humrep/deaeXXX>
- World Health Organization (WHO), 2020. *Safe management of wastes from health-care activities*.
- World Health Organization (WHO), 2021. *Obesity and overweight*.
- World Health Organization (WHO), 2022. *Body mass index classification guidelines*.
- World Health Organization (WHO), 2023. *Anaemia in women and children: Global health estimates*.
- Yu, C., Wu, H., Sun, X., Cao, M., & Yuan, J. (2025). The association between obesity-related indicators and female infertility: NHANES 2013–2018. *Frontiers in Endocrinology*, 16, 1588965. <https://doi.org/10.3389/fendo.2025.1588965>
- Yusuf, A.M. *et al.*, (2024). BMI and haematological indices. *African Health Sciences*, 24(1), pp.210–218.