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RESEARCH

# Obesity is associated with anaemia and iron deficiency indicators among women in the rural Free State, South Africa

**EM Jordaan[a*], VL Van den Berg[a], FC Van Rooyen[b] and CM Walsh[a]**

[a]*Department of Nutrition and Dietetics, University of the Free State, Bloemfontein, South Africa*
[b]*Department of Biostatistics, University of the Free State, Bloemfontein, South Africa*
**Corresponding author, email: cronjeem@ufs.ac.za*



**Objective:** Obesity and anaemia remain global public health problems, holding major consequences for human health. The objective was to determine body composition, prevalence of anaemia and iron deficiency, contraception use and associations between variables in rural women in the Free State, South Africa.
**Design:** A cross-sectional study design was applied.
**Setting:** The study was undertaken in rural Trompsburg, Philippolis and Springfontein.
**Subjects:** A total of 134 HIV-uninfected non-pregnant females, aged between 25 and 49 years participated.
**Exposure and outcome measures:** Data were collected on anthropometry, contraception use and biochemical markers of anaemia, iron deficiency and inflammation.
**Results:** Median body mass index (BMI) (28.7 [24.2, 34.7] kg/m$^2$), waist circumference (90.8 [80.9, 103.0] cm) and body fat percentage (38.8 [34.3, 42.1] %) were classified as unhealthy. Only 2/134 had iron deficiency and 1/134 iron deficiency anaemia. Overall, 3.8% had low red cell folate levels. Almost half (45.0%) had elevated C-reactive protein (CRP) levels. More than half (54.1%) reported that they regularly menstruate and 71.6% currently or had previously used injectable contraceptives. Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and transferrin saturation were significantly associated with BMI, waist circumference and body fat percentage.
**Conclusion:** A predominant pattern of malnutrition, characterised by overweight and obesity, was prevalent. Risk for iron deficiency was associated with obesity. Prevalence of iron deficiency could be underestimated due to the large percentage with elevated CRP levels. Interventions should aim to improve the nutritional status of these women in order to reduce their risk for both chronic diseases and anaemia.

**Keywords:** anaemia, body composition, folate, iron, iron deficiency

## Introduction

Populations undergoing nutrition transitions present with a high prevalence of chronic diseases associated with obesity, as well as high rates of micronutrient deficiencies, including iron deficiency.[1] Obesity and iron deficiency remain major independent contributing factors to the global burden of disease.[2,3] At present, obesity is considered a global pandemic,[3] whereas — worldwide — iron deficiency remains the most prevalent single micronutrient deficiency.[2] Obesity and iron deficiency have also been linked on a molecular level with the one affecting the other, as obesity increases inflammation and thereby increases ferritin, which in turn promotes sequestering of iron by macrophages and also reduces iron absorption in the gut.[4]

In some cultures, obesity is more culturally and aesthetically acceptable, even sought after. Elevated body mass index (BMI) is, however, associated with increased risk for chronic disease.[5]

Contraception may lower iron deficiency anaemia risk by reducing the number of pregnancies and the time interval between consecutive pregnancies.[6] The amount of blood lost during menstruation may also be reduced with contraceptive use.[6,7] An association may thus exist between contraceptive use and improved haemoglobin status.[7]

Research on nutritional anaemias mainly focuses on iron-deficiency anaemia. Globally, approximately 111 000 deaths among pregnant women are attributed to iron-deficiency anaemia each year.[8] Unfortunately, few global data exist on the contribution of folate deficiency towards the development of anaemia.[9]

Associations between obesity and iron deficiency have been described in the literature.[10–12] No studies have, however, investigated this relationship in women, particularly women of childbearing age, in South Africa. This study thus aimed to determine the prevalence of anaemia, iron deficiency and inflammation as well as body composition and associations between these variables as well as contraceptive use in women aged 25–49 years in three rural towns in the southern Free State.

## Method

### *Research approach*

The work reported in this article formed part of the 'Assuring Health for All in the Free State' (AHA-FS) project, an epidemiological study aimed at determining how living in rural and urban areas affects lifestyle and indicators of health. All households in the townships (excluding farms) in the rural towns of Trompsburg, Philippolis and Springfontein in the Free State were eligible to participate in the main study conducted in 2007, as these communities were in the process of undergoing transitions in lifestyle already experienced by populations living in formal settlements.[13]

For the main study, sociodemographic and household food security questionnaires were completed for each household. Individual questionnaires included reported health status, dietary intake and physical activity. All participants underwent a medical examination, anthropometric evaluation and blood sampling. All questionnaires were completed in a structured interview. Where necessary, Sotho, Tswana and Xhosa interpreters assisted.

To our knowledge, few studies have been conducted to determine the relationship between biochemical markers for anaemia and anthropometric status, and thus the aim of this study was to evaluate anthropometric variables, contraceptive use and anaemia, iron deficiency and inflammation in women between 25 and 49 years in these areas in a cross-sectional design.

### Sampling

From the main study, women aged 25–49 years who were HIV-uninfected, gave informed consent and were not pregnant at the time of data collection were selected for the nested study, resulting in a final sample of 134 women.

### Methodology

Height, weight and waist circumference, as well as triceps, biceps, subscapular and suprailiac skinfolds, were obtained using standardised measuring techniques.[14] Weight and height measurements were used to calculate BMI. BMI was categorised as underweight (< 18.5 kg/m$^2$), normal weight (18.5–24.99 kg/m$^2$), overweight (25.0–29.99 kg/m$^2$), obese class 1 (30.0–34.99 kg/m$^2$), obese class 2 (35.00–39.99 kg/m$^2$) and obese class 3 (≥ 40.00 kg/m$^2$).[15]

Waist circumference was used to assess body fat distribution and classified as normal (< 80 cm), at risk (80–87 cm) and high risk (≥ 88 cm).[14]

The sum of four skinfolds was used to calculate body fat percentage.[16] Body fat percentages were classified as too low (≤ 8%), lower acceptable range (9–23%), upper acceptable range (24–31%) and too high (≥ 32%).

Fasting blood samples were used to measure full blood count, serum ferritin concentration, transferrin saturation and red cell folic acid levels. Respondents fasted overnight with blood samples being collected by staff and registrars from the Department of Chemical Pathology, University of the Free State, the next morning. Samples were stored immediately in ice-filled containers and transported to the laboratory. Samples were centrifuged within four hours of collection and stored at −80°C. All samples were analysed according to standard techniques at the accredited National Health Laboratory Service (NHLS) Laboratory at the University of the Free State. Full blood counts were obtained from blood collected in EDTA-containing tubes and determined using the Roche Sysmex XT 2000i® analyser, while ferritin and transferrin saturation were determined using the BN Prospec System nephelometric technology. Serum folate concentrations were measured using the Bayer Advia Centaur System.

**Table 1:** Age and anthropometric characteristics of the study population

| Variable | *n* | Median (25th, 75th) |
|---|---|---|
| Age (years) | 134 | 41.0 (36.0, 46.0) |
| BMI (kg/m$^2$) | 130 | 28.7 (24.2, 34.7) |
| Waist circumference (cm) | 130 | 90.8 (80.9, 103.0) |
| Body fat percentage (%) | 123 | 38.3 (34.3, 42.1) |

The WHO reference values were used to define anaemia (haemoglobin < 12.0 g/dl), iron deficiency (ferritin < 15.0 ng/ml) and iron deficiency anaemia (ferritin < 15.0 ng/ml and haemoglobin < 12.0 g/dl).[2]

C-reactive protein (CRP) was determined by means of the immunoturbidimetric method and was considered elevated if greater or equal to 5 mg/l.[17]

Information related to menstruation and contraceptive use was obtained from the reported health questionnaire.

### Study procedures

All adults between 25 and 64 years of age in the three areas were invited to participate in the main AHA-FS study. Data were obtained at various research stations at the community halls in each of the rural areas. ID documents were screened to ensure that participants met the criteria for age.

Confidentiality was ensured by assigning a specific number to each respondent. Approval was obtained from the Ethics Committee of the Faculty of Health Sciences of the University of the Free State (ETOVS number 21/07), the Department of Health and local municipalities. Participation was voluntary.

### Statistical analysis

Statistical analysis was conducted using the Predictive Analytics SoftWare (PASW) Statistics Student version 22.0 by Statistical Package for the Social Sciences® (SPSS) (IBM Corp, Armonk, NY, USA). Categorical data were reported as frequencies and

**Table 2:** Categories of anthropometric variables, menstruation and contraceptive use

| Characteristics | *n* (%) |
|---|---|
| BMI (kg/m$^2$) | |
| Underweight (< 18.5) | 9 (6.9) |
| Normal weight (18.5–24.99) | 29 (22.3) |
| Overweight (25.0–29.99) | 33 (25.4) |
| Obesity class I (30.0–34.99) | 27 (20.8) |
| Obesity class II (35.0–39.99) | 13 (10.0) |
| Obesity class III (≥ 40) | 19 (14.6) |
| Waist circumference (cm) | |
| Normal (< 80) | 27 (20.8) |
| At risk (80–87) | 28 (21.5) |
| High risk (≥ 88) | 75 (57.7) |
| Body fat percentage (%) | |
| Too low (≤ 8) | 0 (0) |
| Lower acceptable range (9–23) | 2 (1.6) |
| Upper acceptable range (24–31) | 15 (12.2) |
| Too high (≥ 32) | 106 (86.2) |
| Still menstruated regularly | |
| Yes | 72 (54.1) |
| No | 61 (45.9) |
| Currently or had previously used injectable contraceptives | |
| Yes | 96 (71.6) |
| No | 38 (28.4) |

percentages. Continuous data were distributed non-normally and were reported as medians and interquartile ranges. The Kruskal–Wallis test and post-hoc Dunn's test were used to compare iron and anaemia status markers among anthropometric categories. The type I error rate was set at 5% ($p < 0.05$).

## Results

The median age of the women in the current study was 41 years. All median values for the anthropometric measurements were in the unhealthy categories (Table 1).

The majority (70.8%) of women had BMI values above normal (Table 2). Almost 60% presented with waist circumference measurements in the high-risk category, while almost 90% presented with body fat percentages in the too high range.

Overall, 45.9% of the women did not menstruate regularly, and 71.6% currently or had previously used injectable contraceptives.

Only 4.6% of women had low haemoglobin levels (Table 3), with even fewer presenting with low mean corpuscular volume (MCV) (3.1%) and mean corpuscular haemoglobin (MCH) (7.6%) levels. Elevated MCH levels were present in 25.2%.

Low transferrin saturation was present in 12.5% of the sample. Three women (4.1%) presented with low ferritin levels. Of these three, one woman (0.7%) presented with levels below the reference for both ferritin and haemoglobin (i.e. iron deficiency anaemia) and two women (1.5%) with low ferritin levels only (iron deficiency). Overall, only 4.6% of the women presented with anaemia while 3.8% had low red cell folate levels.

The median for CRP was within the normal range (4.6 mg/l); however, 45.0% of the women presented with elevated CRP (min. 0.0 mg/l; max. 19.5 mg/l).

Statistically significant, generally inverse associations were found between BMI categories and MCV ($p = 0.0001$), MCH ($p = 0.0001$) and transferrin saturation ($p = 0.011$). These levels were, however, still within the normal ranges (Table 4).

Significant associations were also found between waist circumference categories and MCV ($p = 0.003$), MCH levels ($p = 0.001$) and transferrin saturation ($p = 0.002$), with these parameters all decreasing as waist circumference increased (Table 5).

Similarly, associations between body fat percentage and MCV ($p = 0.025$), MCH levels ($p = 0.019$) and transferrin saturation ($p = 0.013$) were also identified. MCV and transferrin saturation again decreased with increasing body fat percentage. MCH levels were significantly different in women with body fat percentages in the upper acceptable range (31.8 pg/cell) and too high (30.1 pg/cell) body fat percentage range (Table 6).

A significant association was found between haemoglobin levels and whether women menstruated regularly or not ($p = 0.008$), with no significant association between haemoglobin levels and contraceptive use ($p = 0.847$). Haemoglobin levels were lower in those women who menstruated regularly compared with those who did not. A significant association was also found between ferritin levels and whether women had elevated CRP or not ($p = 0.044$).

## Discussion

Generally, inverse associations were found between MCV, MCH and transferrin saturation with categories of BMI, waist circumference and body fat percentage, with blood markers being lower in the higher, unhealthy categories.

Although obesity and iron deficiency usually represent opposite ends of the spectrum of malnutrition, some studies have shown a link between these two conditions.[10–12] Very few studies have reported on the relationship between transferrin saturation, MCV, MCH and anthropometric variables, with most referring only to haemoglobin. Some studies have reported a significant positive association between haemoglobin and overweight and obesity, central obesity[18] and body fat percentage[19] as well as serum ferritin concentrations and obesity.[1] A study conducted among adults in Washington, DC did, however, find that MCV and transferrin saturation decreased as BMI increased.[20] A study that looked at data of men and women 25–55 years old from the National Health and Nutrition Examination Survey in the United States' dataset also found that MCV and MCH levels decreased with higher waist circumferences, similar to the results of the current study.[21] No studies on the association between body fat percentage and MCV, MCH and transferrin saturation could be found.

Few women in the current study presented with low ferritin levels, indicative of low iron stores. When compared with the South African National Health and Nutrition Examination Survey (SANHANES-1), where 13.5% of women aged 16–35 years living in informal rural areas had low serum ferritin levels,[22] the women in the current study appeared to have much higher iron stores. Significant associations between anthropometric variables and markers of iron status may be due to inflammation, as various studies conducted in obese adults have shown increased levels of pro-inflammatory molecules, which may impair iron status by reducing the bioavailability of iron.[10–12] Since ferritin is an acute-phase protein that is sensitive to inflammation, Thurnham *et al*. (2015) have proposed a method for correcting ferritin for inflammation by using CRP and α1-acid glycoprotein (AGP).[23] Unfortunately, AGP was not measured as part of the main study and adjusted ferritin could therefore not be determined. It is, however, important to consider that almost a third of the women in this study presented with elevated ferritin levels. Considering that CRP was elevated in almost half (45.0%) of the women, and a significant association was found between whether CRP was elevated or not and ferritin levels, prevalence of iron deficiency could thus be underestimated.

However, a recent meta-analysis of all controlled studies on adult obesity and low iron stores concluded that decreased transferrin saturation is consistent with the mechanism of obesity-related inflammation.[9] The high prevalence of obesity in the current study and significant associations between transferrin saturation and BMI, waist circumference and body fat percentage categories thus mirror the findings of other studies.

The older median age in the current study may also partly explain differences in the prevalence of anaemia and iron deficiency, as well as low iron stores. When comparing the number of women in each age range with that of the SANHANES-1 study where an approximately similar number of women were included in the 25–34 years and 35–44 year groups,[22] more older women (35–49 years) were included in the current study. Women of younger fertile age have a

**Table 3:** Micronutrient and anaemia status markers

| Blood samples | Normal reference value[2,17] | *n* | Median | Low (%) | Normal (%) | High (%) |
|---|---|---|---|---|---|---|
| Haemoglobin | > 12.0 g/dl | 130 | 13.8 (13.3, 14.5) | 4.6 | 95.4 | – |
| Haematocrit | > 0.371 l/l | 131 | 0.429 (0.409, 0.446) | 3.1 | 96.9 | – |
| MCV | 79.1–98.9 fl | 131 | 93.8 (89.7, 98.4) | 3.1 | 77.1 | 19.8 |
| MCH | 27.0–32.0 pg/cell | 131 | 30.4 (28.8, 32.2) | 7.6 | 67.2 | 25.2 |
| Transferrin saturation | > 15% | 74 | 26.1 (18.9, 34.8) | 12.2 | 87.8 | – |
| Ferritin | 15–150 ng/ml | 74 | 94.0 (48.5, 180.0) | 4.1 | 64.9 | 31.1 |
| Red cell folate | > 372 nmol/l | 131 | 575.3 (487.8, 674.7) | 3.8 | 96.2 | – |
| CRP | 5 mg/dl | 120 | 4.6 (1.4, 8.0) | – | 55.0 | 45.0 |

greater risk for developing anaemia, particularly iron deficiency anaemia, as a result of losses occurring during menstruation.[7] A much higher percentage (9.7%) of South African women of reproductive age suffered from iron deficiency anaemia in the SANHANES-1.[22]

Only a small percentage of women in the current study suffered from anaemia (Table 3), which is much lower than that of women in the SANHANES-1 where 24.7% of women aged 25–34 years and 23.1% of women aged 35–44 years were reported to be anaemic.[17] The South Africa Demographic and Health Survey (SADHS) of 2016 also reported a much higher prevalence of anaemia amongst women aged 25–34 years (33.0%), 35–44 years (33.8%) and 45–54 years (29.0%).[22]

Possible reasons for this difference could be that almost half of the women in the current study did not menstruate regularly and a large proportion made use of injectable contraceptives. Differences in cut-off values used to identify anaemia may also play a role. The significant association found between haemoglobin and whether the women still menstruated regularly, which could indicate that women who still menstruated were more likely to have lower levels of haemoglobin, could also serve as a possible explanation. Other studies did not report on menstruation and contraceptive use, making it difficult to compare results. A study conducted by Yeasmin *et al.* (2010:28)[7] among women aged 20–40 years from a low socioeconomic background in Dhaka, Bangladesh, found that women who used oral contraceptives had significantly higher haemoglobin levels than those who did not. Another study conducted amongst women aged 15–49 years in Tanzania also found that oral contraceptive use was inversely associated with markers of iron status.[24] The current study did not find a significant association between contraceptive use and haemoglobin levels.

Deficiencies of other micronutrients may also lead to the development of anaemia. A quarter (25.2%) of the women in the current study had higher levels of MCH, which is seen in macrocytic anaemia and may result from a vitamin B12 or folate deficiency. Red cell folate levels below the reference value were found in 3.8% of the women, which is much lower than the estimated prevalence of folate deficiency which can range between 25% and 72% among women of reproductive age living in developing countries.

Overweight (25.4%) and obesity (45.4%) prevalence among women included in the current study was similar to the findings of the SANHANES-1 where 28.0% and 36.3% of women aged 25–34 years were overweight or obese respectively. Among women aged 35–44 years, 26.4% were overweight and 44.8% were obese.[22] The SADHS, conducted in 2016, found that the mean BMI among non-pregnant South African women aged 25–34 years was 29.0 kg/m$^2$ (overweight), 30.8 kg/m$^2$ (obese) among women 35–44 years and 31.0 kg/m$^2$ (obese) among women 45–54 years,[25] similar to the median BMI (28.7 kg/m$^2$) among the women in the current study. Among non-pregnant women in the Transition and Health During Urbanisation of South Africans (THUSA) study of African descent, 26.8% and 24.6% aged 25–34 years, 31.1% and 39.0% aged 35–44 years, and 25.0% and 35.2% aged 45–54 years were overweight or obese, respectively.[5]

Almost 60% of the women presented with a waist circumference in the high-risk category for developing chronic diseases due to obesity. The median waist circumference was 90.8 cm, also within the high-risk category. These findings were again similar to that of the SADHS of 2003 where the mean waist circumference measurements were 82.3 cm in women 25–34 years, 85.1 cm in women 35–44 years, and 88.4 cm in women 45–54 years.[26] These results were also similar to those of the SANHANES-1 where the mean waist circumference in women aged 25–34 years was 87.7 cm and in women aged 35–44 years was 90.9 cm.[22]

The median body fat percentage of the women in the current study was 38.3%, which falls in the too high, unhealthy category with almost 90% of the women falling in this range. Similarly, the mean body fat percentage among African women in a study conducted on South African women from the Cape Town Metropole Area with a mean age of 40 years was 34.0%.[27]

The small sample size and older median age of participants proved to be the greatest limitation of the current study, probably impacting on representativity of results. We believe that this study is still of value as it gives an overview of the prevalence of anaemia and obesity as well as the potential relationship between these variables in these women, which would otherwise not be known.

## Conclusion and recommendations

Results of this study suggest that there was a predominant pattern of malnutrition, characterised by overweight and obesity, high rates of abdominal obesity and unhealthy body fat percentages, as well as inflammation, among the women. These women were, therefore, at high risk for developing chronic diseases of lifestyle. Iron deficiency, iron deficiency anaemia and folate deficiency prevalence was low, which could be attributed to almost half of the women not menstruating anymore and the older median age compared with that of other studies conducted on women of childbearing age. The

Table 4: Associations between blood parameters and BMI categories

| Variables | N | Median (25th, 75th) | *p*-value |
|---|---|---|---|
| Haemoglobin levels across BMI categories (g/dl): | | | 0.129 |
| Underweight | 9 | 13.5 (13.0, 14.6) | |
| Normal weight | 27 | 14.4 (13.5, 14.7) | |
| Overweight | 32 | 14.1 (13.1, 15.0) | |
| Obese class 1 | 27 | 13.6 (12.8, 14.1) | |
| Obese class 2 | 12 | 13.9 (13.4, 14.2) | |
| Obese class 3 | 19 | 13.8 (13.2, 14.4) | |
| Haematocrit levels across BMI categories (l/l): | | | 0.600 |
| Underweight | 9 | 0.416 (0.403, 0.452) | |
| Normal weight | 28 | 0.438 (0.410, 0.447) | |
| Overweight | 32 | 0.430 (0.401, 0.458) | |
| Obese class 1 | 27 | 0.424 (0.410, 0.435) | |
| Obese class 2 | 12 | 0.428 (0.415, 0.447) | |
| Obese class 3 | 19 | 0.434 (0.407, 0.445) | |
| MCV levels across BMI categories (fl): | | | 0.0001* |
| Underweight | 9 | 98.6[a] (93.1, 103.9) | |
| Normal weight | 28 | 97.4[b] (93.0, 101.6) | |
| Overweight | 32 | 92.9[a,b,c] (88.7, 98.6) | |
| Obese class 1 | 27 | 90.9[c] (86.0, 94.6) | |
| Obese class 2 | 12 | 93.8[a,b,c] (92.6, 97.5) | |
| Obese class 3 | 19 | 90.5[d] (87.8, 95.2) | |
| MCH levels across BMI categories (pg/cell): | | | 0.0001* |
| Underweight | 9 | 31.5[b] (30.1, 33.7) | |
| Normal weight | 28 | 31.7[a] (30.3, 33.2) | |
| Overweight | 32 | 30.6[a,b,c] (28.8, 32.1) | |
| Obese class 1 | 27 | 29.4[c] (27.3, 31.2) | |
| Obese class 2 | 12 | 30.3[a,b,c] (29.9, 31.3) | |
| Obese class 3 | 19 | 29.2[d] (28.4, 30.5) | |
| Transferrin saturation across BMI categories (%): | | | 0.011* |
| Underweight | 3 | 42.0[a,b] (27.0, 42.0) | |
| Normal weight | 14 | 31.9[a] (23.7, 50.6) | |
| Overweight | 15 | 28.9[a,b] (24.5, 35.1) | |
| Obese class 1 | 16 | 19.8[b] (15.4, 27.1) | |
| Obese class 2 | 6 | 28.5[a,b] (15.5, 34.7) | |
| Obese class 3 | 16 | 21.5[a,b] (17.1, 31.8) | |
| Ferritin levels across BMI categories (ng/ml): | | | 0.137 |
| Underweight | 3 | 127.0 (56.0, 134.0) | |
| Normal weight | 14 | 179.5 (86.5, 666.5) | |
| Overweight | 15 | 98.0 (49.0, 168.0) | |
| Obese class 1 | 16 | 76.5 (36.5, 163.3) | |
| Obese class 2 | 6 | 89.0 (54.5, 165.5) | |
| Obese class 3 | 16 | 49.0 (28.3, 215.0) | |
| Red cell folate levels across BMI categories (nmol/l): | | | 0.809 |
| Underweight | 9 | 560.0 (504.3, 693.9) | |
| Normal weight | 28 | 603.8 (518.0, 696.7) | |
| Overweight | 32 | 557.1 (440.6, 654.1) | |
| Obese class 1 | 27 | 541.6 (487.8, 646.9) | |
| Obese class 2 | 12 | 556.6 (418.5, 780.7) | |
| Obese class 3 | 19 | 575.3 (460.3, 682.7) | |

Note: Values in one group with different superscript alphabetical letters differ significantly from each other.

mandatory micronutrient fortification of certain staple foods may also have improved micronutrient status. However, the prevalence of iron deficiency may have been underestimated when ferritin was used as marker. Transferrin saturation may, in this case, give a better reflection of the prevalence of iron deficiency. Significant associations between BMI, waist circumference and body fat percentage categories and MCV, MCH and transferrin saturation could indicate that obesity is associated with poorer iron status and anaemia. A significant association was also found between elevated ferritin and elevated CRP levels.

Since haemoglobin levels below normal cut-off values do not identify the type of anaemia, it is important for future research to include other parameters of iron and folate status. Culturally

Table 5: Associations between blood parameters and waist circumference categories

| Variables | *n* | Median (25th, 75th) | *p*-value |
|---|---|---|---|
| Haemoglobin levels across waist circumference categories (g/dl): | | | 0.629 |
| Normal | 27 | 13.6 (13.0, 14.6) | |
| At risk | 30 | 13.7 (13.3, 14.5) | |
| High risk | 69 | 14.0 (13.4, 14.5) | |
| Haematocrit levels across waist circumference categories (l/l): | | | 0.259 |
| Normal | 28 | 0.418 (0.398, 0.447) | |
| At risk | 30 | 0.425 (0.409, 0.444) | |
| High risk | 69 | 0.434 (0.416, 0.447) | |
| MCV levels across waist circumference categories (fl): | | | 0.003* |
| Normal | 28 | 97.3[a] (92.8, 100.7) | |
| At risk | 30 | 96.7[a,b] (91.5, 98.9) | |
| High risk | 69 | 91.6[b] (87.8, 95.3) | |
| MCH levels across waist circumference categories (pg/cell): | | | 0.001* |
| Normal | 28 | 31.6[a] (30.2, 32.8) | |
| At risk | 30 | 31.1[a,b] (30.1, 32.6) | |
| High risk | 69 | 29.6[b] (28.4, 30.9) | |
| Transferrin saturation across waist circumference categories (%): | | | 0.002* |
| Normal | 12 | 39.0[a] (28.1, 45.5) | |
| At risk | 14 | 29.9[a,b] (19.6, 35.6) | |
| High risk | 45 | 24.5[a,b] (16.1, 31.9) | |
| Ferritin levels across waist circumference categories (ng/ml): | | | 0.434 |
| Normal | 12 | 129.0 (70.0, 182.8) | |
| At risk | 14 | 88.0 (46.0, 222.8) | |
| High risk | 45 | 92.0 (43.0, 196.0) | |
| Red cell folate levels across waist circumference categories (nmol/l): | | | 0.494 |
| Normal | 28 | 603.0 (518.0, 699.3) | |
| At risk | 30 | 598.2 (488.6, 634.7) | |
| High risk | 69 | 576.1 (454.7, 684.5) | |

Note: Values in one group with different superscript alphabetical letters differ significantly from each other.

**Table 6:** Associations between blood parameters and body fat percentage categories

| Variables | *n* | Median (25th, 75th) | *p*-value |
|---|---|---|---|
| Haemoglobin levels across body fat percentage categories (g/dl): | | | 0.808 |
| Unhealthy, too low | 0 | | |
| Acceptable range, lower end | 2 | 13.5 (12.8,*) | |
| Acceptable range, upper end | 15 | 13.6 (13.2, 14.6) | |
| Unhealthy, too high | 103 | 13.8 (13.3, 14.5) | |
| Haematocrit levels across body fat percentage categories (l/l): | | | 0.891 |
| Unhealthy, too low | 0 | | |
| Acceptable range, lower end | 2 | 0.425 (0.393,*) | |
| Acceptable range, upper end | 15 | 0.421 (0.404, 0.447) | |
| Unhealthy, too high | 104 | 0.430 (0.409, 0.445) | |
| MCV levels across body fat percentage categories (fl): | | | 0.025* |
| Unhealthy, too low | 0 | | |
| Acceptable range, lower end | 2 | 99.7 $^{a,b}$(98.5,*) | |
| Acceptable range, upper end | 15 | 97.6$^{a}$ (93.2, 102.0) | |
| Unhealthy, too high | 104 | 93.0$^{b}$ (88.8, 98.1) | |
| MCH levels across body fat percentage categories (pg/cell): | | | 0.019* |
| Unhealthy, too low | 0 | | |
| Acceptable range, lower end | 2 | 31.7$^{a,b}$ (30.6,*) | |
| Acceptable range, upper end | 15 | 31.8$^{a}$ (31.1, 33.3) | |
| Unhealthy, too high | 104 | 30.1$^{b}$ (28.6, 31.6) | |
| Transferrin saturation across body fat percentage categories (%): | | | 0.013* |
| Unhealthy, too low | 0 | | |
| Acceptable range, lower end | 0 | | |
| Acceptable range, upper end | 7 | 36.0$^{a}$ (28.2, 44.1) | |
| Unhealthy, too high | 60 | 25.2$^{b}$ (17.4, 34.0) | |
| Ferritin levels across body fat percentage categories (ng/ml): | | | 0.114 |
| Unhealthy, too low | 0 | | |
| Acceptable range, lower end | 0 | | |
| Acceptable range, upper end | 7 | 134.0 (127.0, 286.0) | |
| Unhealthy, too high | 60 | 88.0 (46.3, 176.0) | |
| Red cell folate levels across body fat percentage categories (nmol/l): | | | 0.541 |
| Unhealthy, too low | 0 | | |
| Acceptable range, lower end | 2 | 681.4 (556.0,*) | |
| Acceptable range, upper end | 15 | 908.8 (508.8, 701.9) | |
| Unhealthy, too high | 104 | 576.6 (461.1, 674.0) | |

Note: Values in one group with different superscript alphabetical letters differ significantly from each other.
*No 75th available.

sensitive and sustainable community-based interventions need to be planned and implemented in the study area, based on the findings of the current study. Interventions should focus on addressing the problem of obesity through changing perceptions of these women regarding the health effects thereof, as well as promoting physical activity along with an appropriate diet and lifestyle.

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## ORCID

*CM Walsh* http://orcid.org/0000-0001-5578-9246

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