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# The Association Between Body Composition, Blood Pressure, Fasting Blood Glucose, Lipid Profile and Iron Profile Among Overweight/ Obese University Students

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## Abstract

Evidence from epidemiological studies of association between body composition, blood pressure and metabolic parameters in overweight/obese individuals is of public health interest. This study aimed to determine the association between body composition, blood pressure, fasting blood glucose, lipid profile and iron profile among overweight/obese university students. A total of 28-university students consented to participate in the study. Participants were measured for body composition (body fat percentage and visceral fat percentage) height, weight, waist circumference and blood pressure. Participants' venous blood samples were analysed for fasting blood glucose level, lipid profile and iron profile. Statistical analysis of data used IBM SPSS statistics. Results were presented as mean and standard deviation. Independent sample t-tests or Mann-Whitney tests were used to determine the P-value of variables. Pearson correlation or Spearman rho were used in determining the association between variables. Study findings showed significant difference in height (p=0.000), body fat percentage (p=0.000), systolic blood pressure (p=0.000), HDL-cholesterol (p=0.029), iron (p=0.000), UIBC (p=0.001), saturation (p=0.000), ferritin (p=0.000) between males and females. Body mass index positively correlated with diastolic blood pressure (p=0.001). Body fat percentage negatively correlated with HDL-cholesterol (p=0.002). Visceral fat percentage positively correlated with diastolic blood pressure (p=0.002). Systolic blood pressure positively correlated with ferritin (p=0.001). Diastolic blood pressure positively correlated with triglycerides (p=0.001), iron (p=0.020), saturation (p=0.023), and ferritin (p=0.015), but negatively correlated with HDL-cholesterol (p=0.002), UIBC (p=0.027) and transferrin (p=0.015). In conclusion, this study found an association between body composition, blood pressure, fasting blood glucose, lipid profile and iron profile among university students.

**Keywords:** Body Mass Index; Blood Pressure; Fasting Blood Glucose; Iron Profile; Lipid Profile

## Introduction

Malaysian healthcare is challenged by the increasing trend of overweightness/obesity, abdominal obesity, diabetes, hypertension, heart disease, raised cholesterol levels and anaemia among Malaysians (NIH, 2020). An estimated 1 in 2 adults is overweight or obese (NIH, 2020). According to the National Health and Morbidity Survey (NHMS) 2019, the prevalence risk for abdominal obesity, hypertension, diabetes, high cholesterol, and anaemia were 50%, 30%, 18.3%, 38% and 21.3% (NIH, 2020). Among the 18.3 % of diabetes prevalence, 9.4% have been diagnosed, and 8.9% did not know they had diabetes (NIH, 2020). In the National Diabetes Registry 2020, the registrations were 57% women and 42% men (MOH, 2021). The ethnicity consists of Malay (59%), Chinese (19%), Indian (12%), and other (8%) (MOH, 2021).

The body mass index cut-off in Malaysia public health care uses the Asian cut-off where overweight is ≥ 23 kg/ $m^2$ and obese is ≥ 27.5 kg/ $m^2$ (CPG, 2003). Being overweight or obese increase the risk of non-communicable diseases such as Type 2 diabetes mellitus, coronary heart disease and hypertension (CPG, 2003). In the study by Mohd-Sidik *et al*. (2021), 18.6% obesity prevalence among adults in Selangor, 14.2% of men and

21.1% of women. Tan *et al*. (2019) reported the prevalence of overweight and obesity in undergraduate males is 11.0% to 18.9% and 3.0% to 4.9%. There is a 6.11 % to 8.5 % overweight prevalence and a 0.56% to 3.8% prevalence of obesity among undergraduate females (Tan *et al.*, 2019).

Abdominal obesity can be defined as having a waist circumference of more than 90 cm for males and 80 cm for females (NIH, 2020). Tan *et al*. (2019) reported abdominal obesity prevalence in Malaysia ranges from 11.4% to 18.1%. According to MOH (2015), there was a 2% increase in abdominal obesity prevalence. Lukács *et al.* (2019) reported that abdominal obesity is a strong indicator of metabolic risk factors for metabolic syndrome and cardiovascular disease, particularly among non-obese individuals.

Hypertension is a condition with a high blood pressure value (WHO, 2021). The value to diagnose hypertension is when the systolic blood pressure, the pressure in the blood vessel when the heart contract or beats, is ≥ 140 mmHg, and when diastolic pressure, the pressure in the blood vessel when the heart rest between beats, is ≥ 90 mmHg (WHO, 2021). Khoo *et al*. (2022) observed that from 2006 to 2015, there was a 17% -18.4% prevalence of young-onset hypertension. Obese individuals and diabetic individuals were at a higher risk of developing hypertension (Azahadi Omar *et al.*, 2016).

Diabetes mellitus type two is diagnosed by fasting plasma glucose and random plasma glucose ≥ 7.0 mmol/L (MOH, 2020). The normal HbA1C value is below 5.7% (<39 mmol/mol), the pre-diabetes and diabetes mellitus type two diagnostic HbA1C values 5.7 to 6.3 % (39 to 44 mmol/mol) for pre-diabetes mellitus and 6.3 % (≥ 45 mmol/mol) for diabetes mellitus (MOH, 2020). The gradual fluctuation of fasting glucose correlated with the risk of myocardial infarction, stroke, and all-cause mortality (G. Lee *et al.*, 2018).

Dyslipidaemia can be categorized by the value of total cholesterol > 5.2 mmol/L, low-density lipoprotein cholesterol > 3.4 mmol/L, high-density lipoprotein cholesterol of < 1.0mmol/L (males) and <1.2 mmol/L (females), triglycerides of > 1.7 mmol/L and high-density lipoprotein cholesterol level will depend on the cardiovascular risk (MOH, 2017). Hyperlipidaemia is a type of dyslipidaemia categorized in abnormally high lipid levels in the blood (Wang *et al.*, 2022). High levels of triglycerides, total cholesterol, LDL- cholesterol, or low levels of HDL-cholesterol are all predictors of hyperlipidaemia (Wang *et al.*, 2022).

The condition in which there are not enough healthy red blood cells to carry oxygen in the body is called anaemia (NIH, 2020). A prolonged anaemic condition without treatment can lead to a heart problem (NIH, 2020). There is a 12.6 % anaemia prevalence among younger men and increases in older men and diabetics (Awaluddin *et al.*, 2021). The anaemic prevalence in men is less than in females (Abdullah *et al.*, 2020). Abdullah *et al.* (2020) reported 13.8% anaemia prevalence among Malaysians, Indians are more susceptible, followed by Malays and Chinese (Awaluddin *et al.*, 2021).

Early screening using indicators such as body mass index and measurement of body composition and metabolic profiles is crucial to detect early signs of non-communicable disease among young adults, particularly the overweight and obese who are more susceptible. Appropriate intervention and treatment need to be applied in order to treat and prevent any progression of non-communicable disease. This study aimed to determine body composition, blood pressure, fasting blood glucose, lipid profile and iron profile among 28 overweight/obese university students. The secondary objective of this study is to determine the relationship between body composition, blood pressure, fasting blood glucose, lipid profile and iron profile.

## Method

### Samples

A total of 28 University students participated in this study. The recruitment process used purposive sampling. Participants were provided with information and details on this research. Participants were asked to provide their informed consent to participate voluntarily in the study. Participants were university students, within the age of 18-25 years, and body mass index of more than 23.0 $kgm^{-2}$. Body mass index cut-off value of 23.0 $kgm^{-2}$ to 27.4 $kgm^{-2}$ was categorised as overweight, 27.5 $kgm^{-2}$ to 32.4 $kgm^{-2}$ was categorised as pre-obese, 32.5 $kgm^{-2}$ to 37.4 $kgm^{-2}$ was categorised as obese class I, and more than 37.5 $kgm^{-2}$ was categorised as obese class II (NCCN, 2010).

### Location

This research was conducted at University Malaysia Sabah Kota Kinabalu campus.

### Procedure

Study participants were briefed about the research. All participants provided their sociodemographic information (gender, ethnicity, and year of study). Study participants were measured for body composition (body fat percentage and visceral fat percentage) height, weight, waist circumference and blood pressure. Participants' venous blood samples were drawn for analysis of fasting blood glucose level, lipid profile and iron profile.

## Measurement

### Height, Weight, Body Mass Index and Waist Circumference

Participants were informed on the proper attire for height, weight and waist circumference measurement sessions. Height was measured using a stadiometer, Seca 213 (Seca, Germany). Study participants were barefoot for height measurement. The participant was required to stand straight, looking forward, heels together, arms at the side, and shoulder relax. The participant's head was perpendicular to the horizontal Frankfort bar. The participant's heels, back, shoulder, and head were parallel to the vertical bar of the stadiometer. The participants had to take a deep breath during the height measurement (Lee & Nieman, 2016).

The participant's weight was measured using a digital weighing scale Omron HN-286 (Omron, China). The participant stood straight at the centre of the digital weighing scale without holding anything. The participant was informed to put equal pressure on both standing legs during weight measurement (Lee & Nieman, 2016). Body mass index was calculated using the following formula: BMI= (weight in kg)/(height in meter)$^2$ (Lee & Nieman, 2016).

Waist circumference was determined using a measuring tape, Seca 201 (Seca, Germany). Before the measurement, the participant had removed any outer clothing that restricted the access of the measuring tape to the abdomen, waist, and bare skin. The participant was required to stand upward and relax their abdomen during the measurement. The participant's top right iliac crest, the highest point of the hip bone on the right side, was located. Then the measuring tape was placed at horizontal plane around the abdomen at the level of the iliac crest, not too tight or too loose. The reading of the measurement was recorded at the end of the normal expiration (Lee & Nieman, 2016).

### Body Fat Percentage and Visceral Fat Percentage

The participant's body fat percentage was determined by bioelectrical impedance method using the Omron Body Fat Monitor HBF-302 (Omron Marsusaka Co. Ltd, Japan). Before the measurement, the participant's information (age, gender, and height) was keyed into the Omron Body Fat Monitor HBF-302. The participant had to stand at the centre of the device barefooted. The participant had to put both palms facing downward while grabbing the electrode rod. Then, the participant placed their arms at a 90$^0$ angle perpendicular to the floor (Lee & Nieman, 2016).

### Systolic Blood Pressure and Diastolic Blood Pressure

The participant's blood pressure was measured using an Automatic Blood Pressure Monitor Omron SEM-1 (Omron Marsusaka Co. Ltd, Japan). Before the blood pressure measurement, the participant was informed not to smoke, eat, take caffeine or exercise for at least 30 minutes (MSH, 2011). The participant was asked to stay rested for 10 minutes (Tice *et al.*, 2019). During the blood pressure measurement, subjects were seated with their arm rested at the level of their heart and their feet flat on the ground with legs uncrossed (MSH, 2011). The participant was relaxed during blood pressure measurement (MSH, 2011). The correct bladder cuff size was used and placed at heart level (MSH, 2011). The blood pressure measurement was repeated two times with a gap of 1 to 2 minutes apart at the same position and using the same device (MSH, 2011).

### Venous Blood Sampling for Fasting Blood Glucose, Lipid Profile, and Iron Profile

The participant was instructed to fast 8 - 12 hours before the blood sampling (Tomkins-Lane *et al*., 2015; Batch *et al*., 2014; Hageman *et al*., 2014). Venous blood collection was conducted by qualified medical personnel at Pusat Rawatan Warga, UMS. 10ml of venous blood was drawn. Blood samples were sent to university-accredited hospital lab for analysis (Fasting blood sample, lipid profile, and iron profile). After receiving the blood sampling result, the participants were consulted by qualified medical personnel.

### Ethical Consideration

Ethics approval to conduct the research was granted from UMS Human Ethics Committee (Approval Code: JKEtika 2/21 (15)). All study participants were briefed on and provided with subject information sheet regarding the study. All study participants volunteered to take part in the study and provided their written informed consent before participating in this study.

### Data Analysis

Statistical analysis of data used IBM SPSS statistics. The normality test and the descriptive test were performed. Results were reported in mean and standard deviation. Pearson correlation test or Spearman correlation test was performed to determine the association between variables. Variables found to correlate were further analyzed by comparing means between two groups (low and high values) using an independent t-test test or the Man-Whitney U test depending on normality of the data distribution.

## Results

### Socio-demographic information

**Table 1** shows sociodemographic information of the study participants. In this study, 18 females and 10 males consented to partake in the study. The study participants were Bumiputera Sabah (20), Malay (4), Chinese (3) and Bumiputera Sarawak (1). The participants range from a different year of study. Most participants were overweight (19), pre-obese (7) and obese (2) following the body mass index cut-off point for Malaysia's public health action (NCCN, 2010).

| | **N =28** |
|---|---|
| **Gender** | |
| Female | 18 |
| Male | 10 |
| **Ethnicity** | |
| Bumiputera Sabah | 20 |
| Bumiputera Sarawak | 1 |
| Malay | 4 |
| Chinese | 3 |
| **Year Study** | |
| Foundation of Science | 4 |
| Year 1 | 1 |
| Year 2 | 9 |
| Year 3 | 9 |
| Year 4 | 5 |
| **BMI category** | |
| Overweight (23.0 to 27.4) | 19 |
| Pre-Obese (27.5 to 32.4) | 7 |
| Obese (≥ 32.5) | 2 |

**Table 1:** Sociodemographic information.

There was no significant difference in age (p= 0.077), waist circumference (p=0.090), and body mass index (p=0.737) between males and females (**Table 2**). There was a significant difference in height (p=0.000) between females (1.56 ± 0.06) and males (1.67 ± 0.04). The body fat percentage (p=0.000) of females (33.72 ± 4.05%) was significantly higher than that of males (21.59 ± 3.04 %). There were no significant differences in visceral fat percentage between females (7.05 ± 3.40%) and males (9.03 ± 1.71%). Males (123.2 ± 9.39 mmHg) had significantly higher systolic blood pressure (p=0.000) than females (111 ±6.74 mmHg). However, there was no significant difference in diastolic blood pressure (p=0.457) between females (71.33 ± 9.66 mmHg) and males (75.5 ± 12.43 mmHg). There was no significant difference in fasting blood glucose (p=0.592) between females (4.71± 0.35 mmol/L) and males (4.64 ± 0.23 mmol/L). For lipid profiles, total cholesterol (p=0.215), triglycerides (p=0.429) and LDL-cholesterol (p=0.631) did not differ between males and females. However, HDL-cholesterol (p=0.029) of females (1.60 ± 0.35 mmol/L) was significantly higher than that of males (1.31 ± 0.21 mmol/L). There was significant difference in iron (p=0.000), UIBC (p=0.001), saturation (p=0.000) and ferritin (p=0.000) between males and females. Males had higher iron levels (22.64 ± 7.27 umol/L), saturation (49.50 ± 13.00%), and ferritin (143.72 ± 61.45 ug/L) than females. Females (38.13 ± 11.98 umol/L) had higher UIBC mean than males (23.01 ± 6.33 umol/L). The mean TIBC and transferrin value between females and males showed no statistically significant difference.

| | **Female (N=18)** | **Male (N=10)** | **P-value** |
|---|---|---|---|
| | Mean (standard deviation) | Mean (standard deviation) | |
| Age | 21.72 (1.02) | 20.20 (2.04) | 0.077[2] |
| Weight (kg) | 65.45 (11.80) | 72.58 (6.41) | 0.090[1] |
| Height (m) | 1.56 (0.06) | **1.67 (0.04)** | **0.000[1]** |
| Body mass index (kgm$^{-2}$) | 26.78 (3.59) | 25.91 (1.63) | 0.737[2] |
| Waist Circumference (cm) | 87.56 (9.86) | 84.55 (6.00) | 0.390[1] |
| Body Fat Percentage (%) | **33.72 (4.05)** | 21.59 (3.04) | **0.000[1]** |
| Visceral Fat Percentage (%) | 7.06 (3.40) | 9.03 (1.71) | 0.099[1] |
| Systolic BP (mmHg) | 111.00 (6.75) | **123.20 (9.39)** | **0.000[1]** |
| Diastolic BP (mmHg) | 71.33 (9.66) | 75.50 (12.43) | 0.457[1] |
| Fasting Blood Glucose (mmol/L) | 4.71 (0.35) | 4.64 (0.24) | 0.592[1] |
| Total Cholesterol (mmol/L) | 4.94 (0.70) | 4.52 (1.00) | 0.215[1] |
| Triglycerides (mmol/L) | 1.14 (0.55) | 1.30 (0.63) | 0.429[2] |
| LDL-cholesterol (mmol/L) | 2.82 (0.73) | 2.62 (0.97) | 0.631[2] |
| HDL-cholesterol (mmol/L) | **1.60 (0.35)** | 1.31 (0.21) | **0.029[2]** |

| | Female (N=18) | Male (N=10) | P-value |
|---|---|---|---|
| Iron (umol/L) | 12.29 (6.09) | **22.64 (7.27)** | **0.000$^{1}$** |
| UIBC (umol/L) | **38.13 (11.98)** | 23.01 (6.33) | **0.001$^{1}$** |
| TIBC (umol/L) | 50.42 (8.22) | 45.65 (5.96) | 0.119$^{1}$ |
| Saturation (%) | 25.83 (14.89) | **49.50 (13.00)** | **0.000$^{1}$** |
| Ferritin(ug/L) | 37.54 (50.30) | **143.73 (61.45)** | **0.000$^{2}$** |
| Transferrin (g/L) | 2.82 (0.50) | 2.50 (0.23) | 0.068$^{1}$ |
| Independent Sample T-test$^{1}$, Mann-Whitney test$^{2}$ | | | |

**Table 2:** Body Composition, Fasting Blood Glucose, Blood Pressure, Lipid Profile, and Iron Profile

| N=28 | Systolic BP | Diastolic BP | HDL-cholesterol (mmol/L) | Iron (umol/L) | Saturation (%) | Ferritin (ug/L) |
|---|---|---|---|---|---|---|
| Weight | .381$^{p}$ | .522$^{s}$ | -.492$^{p}$ | .476$^{p}$ | .409$^{p}$ | .398$^{s}$ |
| | 0.045* | 0.004* | 0.008* | 0.010* | 0.031* | 0.036* |
| $^{s}$ Spearman Rho, $^{p}$ Pearson Correlation, $^{*}$ P-value significant (2-tailed) | | | | | | |

**Table 3:** Correlation between weight with systolic blood pressure, diastolic blood pressure, HDL-cholesterol, iron, saturation, and ferritin.

| N=28 | Systolic BP | HDL-cholesterol (mmol/L) | Iron (umol/L) | UIBC (umol/L) | Saturation (%) | Ferritin(ug/L) |
|---|---|---|---|---|---|---|
| Height | .567$^{p}$ | -.381$^{p}$ | .635$^{p}$ | -.445$^{p}$ | .585$^{p}$ | .477$^{s}$ |
| | **0.002*** | **0.046*** | **0.000*** | **0.018*** | **0.001*** | **0.010*** |
| $^{s}$ Spearman Rho, $^{p}$ Pearson Correlation, $^{*}$ P-value significant (2-tailed) | | | | | | |

**Table 4:** Correlation between height with systolic blood pressure, HDL-cholesterol, iron, UIBC, saturation and ferritin.

| N=28 | Systolic BP |
|---|---|
| Waist Circumference | .567$^{p}$ |
| | **0.002*** |
| $^{s}$ Spearman Rho, $^{p}$ Pearson Correlation, $^{*}$ P-value significant (2-tailed) | |

**Table 5:** Correlation between waist circumference and systolic blood pressure

| N=28 | Systolic Blood Pressure | Diastolic Blood Pressure | Total Cholesterol (mmol/L) | Triglycerides (mmol/L) | Iron (umol/L) | UIBC (umol/L) | Saturation (%) |
|---|---|---|---|---|---|---|---|
| Body Mass Index | -.412$^{p}$ | .574$^{s}$ | .381$^{p}$ | .483$^{p}$ | -.440$^{p}$ | .460$^{p}$ | -.461$^{p}$ |
| | **0.029*** | **0.001*** | **0.046*** | **0.009*** | **0.019*** | **0.014*** | **0.014*** |
| Female | 0.569$^{t}$ | **0.015$^{t}$** | 0.851$^{M}$ | 0.092$^{M}$ | 0.925$^{t}$ | 1.000$^{t}$ | 0.815$^{t}$ |
| 18.5 - 27.45 | | | | | | | |
| 27.45 - 34.9 | | | | | | | |
| Male | 0.155$^{t}$ | 0.632$^{t}$ | 0.264$^{t}$ | 0.176$^{t}$ | 0.569$^{t}$ | 0.498$^{t}$ | 0.892$^{t}$ |
| 23.40- 25.80 | | | | | | | |
| 25.9 - 28.3 | | | | | | | |
| $^{s}$ Spearman Rho, $^{p}$ Pearson Correlation, $^{t}$ Independent Sample test P-value significant (2-tailed), $^{M}$ Mann- Whitney Test P-value significant (2-tailed), $^{*}$ P-value significant (2-tailed) | | | | | | | |

**Table 6:** Correlation between body mass index with systolic blood pressure, diastolic blood pressure, total cholesterol, triglycerides, iron, UIBC, and saturation.

| N=28 | HDL- cholesterol (mmol/L) | Iron (umol/L) | Ferritin(ug/L) |
|---|---|---|---|
| Body Fat Percentage | -.562$^{p}$ | .396$^{p}$ | -.549$^{s}$ |
| | **0.002 *** | **0.037 *** | **0.002 *** |
| Female | 0.329$^{t}$ | 0.742$^{t}$ | 0.684$^{M}$ |
| 27.6 - 34.3 | | | |

| | | | |
|---|---|---|---|
| 34.4 - 41.1 | | | |
| Male | **0.031** [t] | 0.148 [t] | 0.942 [t] |
| 17.50 - 22.5 | | | |
| 22.6 - 27.6 | | | |
| [s] Spearman Rho, [p] Pearson Correlation, [t] Independent Sample test P-value significant (2-tailed), [M] Mann-Whitney Test P-value significant (2-tailed), * P-value significant (2-tailed) | | | |

**Table 7:** Correlation between body fat percentage with HDL-cholesterol, iron, and ferritin.

| N=28 | Diastolic Blood Pressure | Ferritin(ug/L) |
|---|---|---|
| Visceral Fat Percentage | .555 [s] | .426 [s] |
| | **0.002*** | **0.024*** |
| Female | **0.016** [t] | 0.805 [M] |
| 4 - 8 | | |
| 9 -14 | | |
| Male | 0.280 [t] | 0.712 [t] |
| 7 - 9.5 | | |
| 9.6 -12.1 | | |
| [s] Spearman Rho, [p] Pearson Correlation, [t] Independent Sample test P-value significant (2-tailed), [M] Mann- Whitney Test P-value significant (2-tailed), * P-value significant (2-tailed) | | |

**Table 8:** Correlation between visceral fat percentage with diastolic blood pressure and ferritin.

| N=28 | HDL- cholesterol (mmol/L) | Iron (umol/L) | UIBC (umol/L) | Saturation (%) | Ferritin (ug/L) |
|---|---|---|---|---|---|
| Systolic BP | -.419 [p] | .581 [p] | -.515 [p] | .603 [p] | .606 [s] |
| | **0.027*** | **0.001*** | **0.005*** | **0.001*** | **0.001*** |
| Female | 0.421 [t] | 0.072 [t] | 0.307 [t] | 0.087 [t] | 0.218 [M] |
| 95 - 121 | | | | | |
| 108 - 121 | | | | | |
| Male | 0.711 [t] | 0.551 [t] | 0.462 [t] | 0.431 [t] | **0.016** [t] |
| 108 - 123 | | | | | |
| 124 - 139 | | | | | |
| [s] Spearman Rho, [p] Pearson Correlation, [t] Independent Sample test P-value significant (2-tailed), [M] Mann- Whitney Test P-value significant (2-tailed), * P-value significant (2-tailed) | | | | | |

**Table 9:** Correlation between systolic blood pressure with HDL-cholesterol, iron, UIBC, saturation and ferritin.

| N=28 | Triglycerides (mmol/L) | HDL-cholesterol (mmol/L) | Iron (umol/L) | UIBC (umol/L) | Saturation (%) | Ferritin (ug/L) | Transferrin (g/L) |
|---|---|---|---|---|---|---|---|
| Diastolic BP | .579 [s] | -.568 [s] | .438 [s] | -.419 [s] | .427 [s] | .453 [s] | -.456 [s] |
| | **0.001*** | **0.002*** | **0.020*** | **0.027*** | **0.023*** | **0.015*** | **0.015*** |
| Female | **0.015** [M] | **0.028** [t] | **0.018** [t] | **0.001** [t] | **0.001** [t] | **0.034** [M] | **0.003** [t] |
| 59 - 76 | | | | | | | |
| 77 - 95 | | | | | | | |
| Male | 0.235 [t] | 0.214 [t] | 0.923 [t] | 0.998 [t] | 0.942 [t] | 0.503 [t] | 0.790 [M] |
| 60 - 80 | | | | | | | |
| 81 - 101 | | | | | | | |
| [s] Spearman Rho, [p] Pearson Correlation, [t] Independent Sample test P-value significant (2-tailed), [M] Mann- Whitney Test P-value significant (2-tailed), * P-value significant (2-tailed) | | | | | | | |

**Table 10:** Correlation between diastolic blood pressure with triglycerides, HDL-cholesterol, iron, UIBC, saturation, ferritin, and transferrin.

| N=28 | Iron (umol/L) | UIBC (umol/L) | Saturation (%) |
|---|---|---|---|
| Triglycerides (mmol/L) | .509 [s] | -.429 [s] | .452 [s] |
| | **0.006*** | **0.023*** | **0.016*** |
| Female | 0.953 [t] | 0.808 [t] | 0.715 [t] |
| 0 - 1.5 | | | |
| 1.6 - 3.1 | | | |
| Male | 0.953 [t] | 0.808 [t] | 0.715 [t] |
| 0 - 1.5 | | | |
| 1.6 - 3.1 | | | |
| [s] Spearman Rho, [p] Pearson Correlation, [t] Independent Sample test P-value significant (2-tailed), [M] Mann- Whitney Test P-value significant (2-tailed), * P-value significant (2-tailed) | | | |

**Table 11:** Correlation between triglycerides with iron, UIBC and saturation.

| N=28 | Iron (umol/L) | UIBC (umol/L) | Saturation (%) | Ferritin(ug/L) | Transferrin (g/L) |
|---|---|---|---|---|---|
| HDL-cholesterol (mmol/L) | -.463 [p] | .430 [p] | -.508 [p] | -.505 [s] | .377 [p] |
| | **0.013*** | **0.023*** | **0.006*** | **0.006*** | **0.048*** |
| Female | 0.171 [t] | 0.410 [t] | 0.142 [t] | 0.110 [M] | 0.363 [t] |
| 1.1 - 1.65 | | | | | |
| 1.66 - 2.16 | | | | | |
| Male | 0.398 [t] | 0.721 [t] | 0.539 [t] | 0.699 [t] | 0.908 [M] |
| 1 - 1.35 | | | | | |
| 1.36 - 1. 71 | | | | | |
| [s] Spearman Rho, [p] Pearson Correlation, [t] Independent Sample test P-value significant (2-tailed), [M] Mann- Whitney Test P-value significant (2-tailed), * P-value significant (2-tailed) | | | | | |

**Table 12:** Correlation between HDL-cholesterol with iron, UIBC, saturation, ferritin, and transferrin.

**Correlation between body composition, fasting blood glucose, lipid profile and iron profile**

Weight positively correlated with systolic blood pressure (r=.381, p=0.045), diastolic blood pressure (r=.522, p=0.004), iron (r=.476, p=0.010), saturation (r=.409, p=0.031) and ferritin (r=.398, p=0.036), but negatively correlated with HDL-cholesterol (r=-.492, p=0.008). Height positively correlated with systolic blood pressure (r=.567, p=0.002), iron (r=.635, p=0.000), saturation (r=.585, p=0.001), and ferritin (r=.477, p=0.010), but negatively correlated with HDL-cholesterol (r=-.381, p=0.046) and UIBC (r=-.445, p=0.018). Waist circumference positively correlated with systolic blood pressure (r=.567, p=0.002).

Body mass index positively correlated with diastolic blood pressure (r=.574, p=0.001), total cholesterol (r=.381, p=0.046), triglycerides (r=.483, p=0.009), and UIBC (r=.460, p=0.014), but negatively correlated with systolic blood pressure (r=-.412, p=0.029), iron (r=-.440, p=0.019), and saturation (r=-.461, p=0.014). There was a significant difference in diastolic blood pressure (p=0.015) between females with low (18.5 - 27.45 $kgm^{-2}$) and high (27.45 - 34.9 $kgm^{-2}$) body mass index.

Body fat percentage positively correlated with iron (r=.396, p=0.037), but negatively correlated with HDL-cholesterol (r=-.562, p=0.002) and ferritin (r=-.549, p=0.002). HDL-cholesterol (p=0.031) was significantly different between males with low (17.50 - 22.5%) and high (22.6 - 27.6 %) body fat percentage.

Visceral fat percentage positively correlated with diastolic blood pressure (r=.555, p=0.002) and ferritin (r=.426, p=0.024). Diastolic blood pressure (p=0.016) was significantly different between females with low (4 – 8%) and high (9 -14%) visceral fat percentages.

Systolic blood pressure positively correlated with iron (r=.581, p=0.001), saturation (r=.603, p=0.001), and ferritin (r=.606, p=0.001), but negatively correlated with HDL-cholesterol (r=-.419, p=0.027) and UIBC (r=-.515, p=0.005). Ferritin (p=0.016) is significantly different in males with low (108 - 123 mmHg) and high (124 - 139 mmHg) systolic blood pressure.

Diastolic blood pressure positively correlated with triglycerides (r=.579, p=0.001), iron (r=.438, p=0.020), saturation (r=.427, p=0.023), ferritin (r=.453, p=0.0215), but negatively correlated with HDL-cholesterol (r=-.568, p=0.028), UIBC (r=-.419, p=0.027), and transferrin (r=-.456, p=0.015). Triglycerides (p=0.015), HDL-cholesterol (p=0.028), iron (p=0.018), UIBC (p=0.001), saturation (p=0.001), ferritin (p=0.034), and transferrin (p=0.003) were significantly different in females with low (59 - 76 mmHg) and high (77 - 95 mmHg) diastolic blood pressure.

Triglycerides positively correlated with iron (r=.509, p=0.006) and saturation (r=.452, p=0.016), but negatively correlated with UIBC (r=-.429, p=0.023). HDL-cholesterol positively correlated with UIBC (r=.430, p=0.023) and transferrin (r=.377, p=0.048), but negatively correlated with iron (r=-.463, p=0.013), saturation (r=-.508, p=0.006) and ferritin (r=-.505, p=0.006).

## Discussion

This study aimed to determine the association between body composition, fasting blood glucose, lipid profile and iron profile among 28 overweight/obese university students. Findings of this study showed no significant differences in age, weight, waist circumference, body mass index, and visceral fat percentages between genders. This study found that females had significantly higher body fat percentage than males. Sukkriang *et al.* (2021) reported that females had larger waist circumference, higher body fat percentage, and lower visceral fat than males. According to Mohd-Sidik *et al*. (2021), women with higher or obese body mass index tend to have low physical activity, albeit having a healthier dietary intake.

This study found that waist circumference positively correlated with systolic blood pressure. This is consistent with findings by Song (2014) in which waist circumference positively correlated with systolic blood pressure among normal-weight and overweight individuals. Lukács *et al*. (2019) reported that a larger waist circumference is associated with the risk of high systolic blood pressure, increased fasting blood glucose, high cholesterol level and high triglycerides. A larger waist circumference is linked to a higher body mass index (Lukács *et al.*, 2019).

This study also found that body mass index is positively associated with diastolic blood pressure, total cholesterol, triglycerides and UIBC, but negatively associated with systolic blood pressure, iron, and saturation. Moreover, there was a significant difference in the mean diastolic blood pressure among females with low and high body mass index. These results are consistent with the suggestion by Sukkriang *et al*. (2021) that obese individuals with higher body mass indexes have high serum triglycerides. Past studies showed that higher body mass index correlated with higher diastolic blood pressure (Landi *et al*., 2018 ; Chen *et al*., 2018; Dua *et al*., 2014). Landi *et al*. (2018) explained that the positive correlation between body mass index and blood pressure causes hypertension. However, Khalid *et al*. (2020) found negative association between body mass index and male's diastolic blood pressure. Choma *et al*. (2015) discovered body mass index links inversely with serum iron, haemoglobin, ferritin, and transferrin saturation but positively correlated with TIBC. Aderibigbe *et al*. (2011) addressed that obese individuals had lower serum iron than normal-weight and pre-obese women.

This study showed that body fat percentage was only positively associated with iron and negatively correlated with HDL-cholesterol and ferritin. Sukkriang *et al*. (2021) reported body fat percentage positively correlated with total cholesterol. Aderibigbe *et al*. (2011) found that high body fat percentages were associated with high ferritin levels. Body mass index and fat percentage may be associated with the induction of non-alcoholic fatty liver disease (NAFLD) (Martins, 2016) that determine diastolic blood pressure, total cholesterol, triglycerides, UIBC, blood pressure, iron, and saturation. The organ for lipid and iron haemostasis is the liver (Martins, 2017), and any changes in liver homeostasis may affect diastolic blood pressure, total cholesterol, triglycerides, UIBC, blood pressure, iron, and saturation.

Visceral fat percentage positively correlated with diastolic blood pressure and ferritin. There is significant difference in diastolic blood pressure between females with low and high visceral fat percentages. Guo *et al*. (2019) observed that men's visceral fat reduction was associated with systolic and diastolic blood pressure improvement. Goswami *et al*. (2020) reported a positive association between visceral fat and hypertension among the indigenous tribal population of Tripura. Sukkriang *et al*. (2021) reported a negative association between visceral fat rating and HDL-cholesterol.

In this current study, males had significantly higher systolic blood pressure than females, but there was no difference in diastolic blood pressure between gender. According to Dua *et al*. (2014), the difference in blood pressure between gender begins during adolescence. Azahadi Omar *et al*. (2016) reported blood pressure differences in gender were more significant during young adulthood. Males were more susceptible to higher systolic blood pressure and diastolic blood pressure due to smoking and drinking habits (Dua *et al*., 2014). Females who benefit from the protective effect of oestrogen tend to have lower blood pressure (Dua *et al.*, 2014). The prevalence of hypertension is also lower in females (Azahadi Omar *et al.*, 2016). The risk of hypertension in Bumiputera was also higher than in another ethnicity in Malaysia (Azahadi Omar *et al.*, 2016).

The findings in this study showed that systolic blood pressure positively correlated with iron, saturation, and ferritin but negatively correlated with HDL-cholesterol and UIBC. Ferritin level in males was significant when compared to low and high systolic blood pressure. Diastolic blood pressure positively correlated with triglycerides, iron, saturation, and ferritin but negatively correlated with HDL-cholesterol, UIBC and transferrin. This study showed significant difference in triglycerides, HDL-cholesterol, iron, UIBC, saturation, ferritin, and transferrin between females with low and high diastolic blood pressure. Results of this study are consistent with work by Zhu *et al*. (2019) that reported diastolic blood pressure positively correlated with serum ferritin. Zhu *et al*. (2019) reported serum transferrin is positively associated with systolic and diastolic blood pressure, which contradicts this study. The increase in transferrin and haemoglobin concentration increases the risk of hypertension (Zhu *et al.*, 2019). Vento *et al*. (2022) reported that an increase in systolic pressure was linked to higher total HDL-cholesterol. Chen *et al.* (2018) also discovered systolic blood pressure positively correlated with total cholesterol. Chen *et al.* (2018) suggested systolic blood pressure positively correlated with body mass index, age, heart rate, total cholesterol, being male, having diabetes, having hypertension, and taking antihypertensive drugs.

Dua *et al*. (2014) suggested systolic and diastolic blood pressure positively correlated with age, anthropometric measures, and fat percentage. Azahadi Omar *et al*. (2016) noted that the development of hypertension progress with age. Past literature showed that serum ferritin was a predictor of hypertension, particularly in middle age Korean men (Kim *et al.*, 2012) and men who are shift workers (D. H. Lee *et al.*, 2018). D. H. Lee *et al*. (2018) noticed that serum ferritin was positively associated with hypertension, while Kim *et al*. (2012) discovered that increased ferritin and TIBC were predictors of hypertension. Wang *et al*. (2019) observed increased ferritin levels and abnormal systolic and diastolic blood pressure in first-time male blood donors, albeit normal ferritin levels for regular blood donors. He *et al*. (2021) noticed that higher triglycerides and lower HDL-cholesterol increased the risk of new-onset hypertension in the Chinese community. Mohamed-Yassin *et al*. (2021) found elevated triglyceride among participants with hypertension.

Study participants' fasting blood glucose between gender was in the normal range and showed no difference. In previous studies, either moderate or high physical activity (Teh *et al*., 2015) or frequent physical activity for four or more days (Sedodo *et al*., 2020) lowered fasting blood glucose. According to Sukkriang *et al.* (2021), females have a lower fasting blood sample and fasting blood glucose is positively correlated with visceral fat rating. This study shows that fasting blood sugar has no association with other variables, albeit visceral fat in this study was lower. Mehdad *et al.* (2012) found that among overweight/ obese adolescent females, elevated fasting blood glucose correlated to higher fat mass, higher body fat percentage, greater body mass index, and larger waist circumference. There was no correlation between fasting blood glucose and fat mass, body fat percentage, body mass index, or larger waist circumference found in adolescent males (Mehdad *et al.*, 2012). Research findings by Lee *et al.* (2011) showed that hypertensive people with high fasting glucose levels and high body mass index had a 40-fold increased risk of developing diabetes mellitus.

This current study reported that total cholesterol, triglycerides, and LDL-cholesterol did not differ between gender. Females showed significantly higher blood HDL-cholesterol levels than males. Total cholesterol, triglycerides, and LDL-cholesterol were also in normal ranges. However, both genders have HDL-cholesterol levels higher than the normal range. Previous studies show mixed results in HDL-cholesterol between gender. Mohamed-Yassin *et al*. (2021) found that females tended to have lower levels of HDL-cholesterol, lower triglycerides, and lower non-HDL-cholesterol than males. Kim *et al*. (2011) noticed gender differences in HDL-cholesterol among participants below 60 years, with females having a higher HDL-cholesterol. Kim *et al*. (2011) explained that the gender difference was due to oestrogens hormone, which functions in reducing the metabolic activity of macrophage by lipid accumulation, while testrogen promotes it. The high values of HDL-cholesterol may be due to higher dietary fat intake (Kim *et al.*, 2011).

Previous literature reported that males tend to have higher HDL-cholesterol and LDL-cholesterol levels than females (Ariaratnam *et al*., 2017 ; Sukkriang *et al*., 2021). Female athletes have lower total cholesterol (Vento *et al.*, 2022), and regular take-out habits tend to influence the higher level of LDL-cholesterol and total cholesterol (Jafri, 2015). Ariaratnam *et al.* (2017) reported that in older age, males and non-Malays have higher triglycerides values.

Triglycerides were positively correlated with iron and saturation but negatively correlated with UIBC. HDL-cholesterol was positively correlated with UIBC but negatively correlated with iron, saturation, and ferritin. This study contradicts He *et al*. (2020) which suggested that triglyceride is negatively associated with serum iron, and high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and total cholesterol are positively correlated with serum iron. Triglycerides over 150mg/dL were significantly associated with lower HDL-cholesterol (Kim *et al*. (2011). He *et al*. (2020) also observed that total cholesterol positively correlated with serum iron. Sawada *et al*. (2020) noted that groups with Iron deficiency without anaemia (IDNA) have higher serum HDL-cholesterol. No association was found between total cholesterol, triglycerides, and LDL-cholesterol in the iron deficiency without anaemia group (Sawada *et al*., 2020). The increased concentration of serum LDL-cholesterol is linked to a higher serum ferritin level (Sawada *et al.*, 2020). There was no correlation between HDL-cholesterol with serum ferritin levels (Sawada *et al.*, 2020).

In this study, males had significantly higher iron, saturation, and ferritin but lower UIBC than females. TIBC and transferrin showed no difference between gender. According to Ajugwo *et al*. (2014), male participants had higher iron and a lower UIBC than female participants but Ajugwo *et al*. (2014) reported significant difference between the TIBC mean value of males and females. For iron status, serum ferritin level was a sign of depleted iron stores or severe risk of iron overload. The risk of iron overload is suspected when serum ferritin exceeds 200 ug/L for males and 150 ug/L for females (WHO, 2011). In this study, the participants have a healthy range of serum ferritin and no sign of iron store depletion (<15 ug/L).

## Conclusion

In conclusion, height, body fat percentage, systolic blood pressure, HDL-cholesterol, iron, UIBC, saturation and ferritin between gender were different. Body mass index was associated with diastolic blood pressure, total cholesterol, triglycerides, UIBC, blood pressure, iron, and saturation. Body fat percentage was associated with iron, HDL-cholesterol, and ferritin. Visceral fat percentages were associated with diastolic blood pressure and ferritin. Systolic blood pressure was associated with iron, saturation, ferritin, HDL-cholesterol, and UIBC. Diastolic blood pressure was associated with triglycerides, iron, saturation, ferritin, HDL-cholesterol, UIBC, and transferrin. Triglycerides was associated with iron and saturation, and UIBC. HDL-cholesterol was associated with UIBC, transferrin, iron, saturation, and ferritin. The study sample size was small and only among university students. Therefore, these study findings cannot be generalized to the whole population. The work described in this article did not include the dietary intake data of the study participants. This is recommended in future publication.

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## References

1. Abdullah, N.Ismail, N.Abd Jalal, N.Mohd Radin, F.Othman, et al. (2020). Prevalence of anaemia and associated risk factors amongst The Malaysian Cohort participants. *Annals of Hemotology*.
2. Aderibigbe, O.R.Pisa, P.T.Mamabolo, R.L.Kruger, Vorster,H.H, et al. (2011). The relationship between indices of iron status and selected anthropometric cardiovascular disease risk markers in an African population: The THUSA study. *Cardiovascular Journal of Africa*, 22:249-256.
3. Ajugwo, A.Ukaji, D.Ajugwo, A.O.Ukaji, D.C.Adinuba, et al. (2014). Iron profile studies of a group of healthy University students. *Public Health View project American Journal of Biology and Life Sciences*, 2(2).
4. Ariaratnam, S.Krishnapillai, A.D.Daher, A.M.Fadzil, M.A.Razali, et al. (2017). Relationship between coping styles and lipid profile among public university staff. *Lipids in Health and Disease*, 16(1).
5. Awaluddin, S.M.Shahein, N.A.Rahim, N.C.A.Zaki, N.A.M.Nasaruddin, et al. (2021). Anemia among men in Malaysia: A population-based survey in 2019. *International Journal of Environmental Research and Public Health*, 18(20).
6. Azahadi Omar, M.Irfanita Irfan, N.Yi Yi, K.Muksan, N.Liana Abdul Majid, et al. (2016). PREVALENCE OF YOUNG ADULT HYPERTENSION IN MALAYSIA AND ITS ASSOCIATED FACTORS: FINDINGS FROM NATIONAL HEALTH AND MORBIDITY SURVEY 2011. *Malaysian Journal of Public Health Medicine*, 16:274-283.
7. Batch, B.C.Tyson, C.Bagwell, J.Corsino, L.Intille, et al. (2014). Weight loss intervention for young adults using mobile technology: Design and rationale of a randomized controlled trial - Cell Phone Intervention for You (CITY). *Contemporary Clinical Trials*, 37:333-341.
8. Chen, H.Zhang, R.Zheng, Q.Yan, X.Wu, et al. (2018). Impact of body mass index on long-term blood pressure variability: A cross-sectional study in a cohort of Chinese adults. BMC Public Health, 18(1).
9. Choma,S.S. R.Alberts,M. Modjadji, S.E.P. (2015). Conflicting effects of BMI and waist circumference on iron status. *Journal of Trace Elements in Medicine and Biology*, 32:73-78.
10. Clinical Practices Guidelines. 2003. *CPG on Management of Obesity*.
11. Dua,S. Bhuker,M. Sharma,P. Dhall,M. Kapoor,S. (2014). Body mass index relates to blood pressure among adults. *North American Journal of Medical Sciences*, 6:89-95.
12. Goswami,B. Reang,T. Sarkar,S. Sengupta,S. Bhattacharjee,B. (2020). Role of body visceral fat in hypertension and dyslipidemia among the diabetic and nondiabetic ethnic population of Tripura-A comparative study. *Journal of Family Medicine and Primary Care*, 9:2885.
13. Guo,X. Xu,Y. He,H. Cai,H. Zhang,J. et al. (2019). Visceral fat reduction is positively associated with blood pressure reduction in overweight or obese males but not females: An observational study. *Nutrition and Metabolism*, 16(1).
14. Hageman,P.A. Pullen,C.H. Hertzog,M. Boeckner,L.S. (2014). Effectiveness of tailored lifestyle interventions, using web-based and print-mail, for reducing blood pressure among rural women with prehypertension: Main results of the Wellness for Women: DASHing towards Health clinical trial. *International Journal of Behavioral Nutrition and Physical Activity*, 11:1-18.
15. He,D. Fan,F. Jia,J. Jiang,Y. Sun,P. et al. (2021). Lipid profiles and the risk of new-onset hypertension in a Chinese community-based cohort. *Nutrition, Metabolism and Cardiovascular Diseases*, 31:911-920.
16. He,L. Zhang,Y. Ru,D. Xue,B. Wen,S. et al. (2020). Serum iron levels are negatively correlated with serum triglycerides levels in female university students. *Annals of Cardiothoracic Surgery*, 9:414-419.
17. Jafri,S.A. 2015. Serum lipid profile of college/university students taking home made food or market fast food. *Pure and Applied Biology*, 4:118-124.
18. Khalid,F. Siddique,A. Siddiqui,J.A. Panhwar,G. Singh,S. et al. (2020). Correlation Between Body Mass Index and Blood Pressure Levels Among Hypertensive Patients: A Gender-Based Comparison. *Cureus*.
19. Khoo,Y.Y. Farid,N.D.N. Choo,W.Y. Omar,A. (2022). Prevalence, awareness, treatment and control of young-onset hypertension in Malaysia, 2006-2015. *Journal of Human Hypertension*, 36:106-116.
20. Kim,H.J. Park, H.A. Cho, Y.G. Kang, Jae Heon Kim, et al. (2011). Gender difference in the level of HDL cholesterol in Korean adults. *Korean Journal of Family Medicine*, 32:173-181.
21. Kim,M.K. Baek,K.H. Song,K.H. Kang,M. ilChoi,J.H. et al. (2012). Increased serum ferritin predicts the development of hypertension among middle-aged men. *American Journal of Hypertension*, 25:492-497.
22. Landi,F. Calvani,R. Picca,A. Tosato,M. Martone,A.M. et al. (2018). Body mass index is strongly associated with

hypertension: Results from the longevity check-up 7+ study. *Nutrients*, 10(12).

**23.** Lee,D.H. Kang,S.K. Choi,W.J. Kwak,K.M. Kang,D. et al. (2018). Association between serum ferritin and hypertension according to the working type in Korean men: The fifth Korean National Health and nutrition examination survey 2010-2012. *Annals of Occupational and Environmental Medicine*, 30(1).

**24.** Lee,G. Kim,S.M. Choi,S. Kim,K. Jeong,S.M. et al. (2018). The effect of change in fasting glucose on the risk of myocardial infarction, stroke, and all-cause mortality: A nationwide cohort study. *Cardiovascular Diabetology*, 17(1).

**25.** Lee,Robert.D. Nieman, David.C. (2016). *Nutritional Assessment*, Mc Graw Hill.

**26.** Lee,W.Y. Kwon,C.H. Rhee,E.J. Park,J.B. Kim,Y.K. et al. (2011). The effect of body mass index and fasting glucose on the relationship between blood pressure and incident diabetes mellitus: A 5-year follow-up study. Hypertension Research, 34:1093-1097.

**27.** Lukács,A. Horváth,E. Máté,Z. Szabó,A. Virág,K. et al. (2019). Abdominal obesity increases metabolic risk factors in non-obese adults: A Hungarian cross-sectional study. *BMC Public Health*, 19(1).

**28.** Malaysia Society of Hypertension. 2011. *CPG Management of Hypertension 3rd Edition*.

**29.** Martins, I. J. (2016). Anti-Aging Genes Improve Appetite Regulation and Reverse Cell Senescence and Apoptosis in Global Populations. Advances in Aging Research, 05(01), 9-26.

**30.** Martins, I. J. (2017). Single Gene Inactivation with Implications to Diabetes and Multiple Organ Dysfunction Syndrome. Journal of Clinical Epigenetics, 03(03).

**31.** Mehdad,S. Hamrani,A. el Kari,K. el Hamdouchi,A. Barakat,A. et al. (2012). Body mass index, waist circumference, body fat, fasting blood glucose in a sample of Moroccan adolescents aged 11-17 years. Journal of Nutrition and Metabolism.

**32.** Ministry of Health. 2020. *Management of Type 2 Diabetes Mellitus* 6th ed., Putrajaya.

**33.** Ministry of Health. 2015. *National Health & Morbidity Survey Volume II: Non-Communicable Disease, Risk Factors & Other Health Problem*.

**34.** Ministry of Health Malaysia 2017. *Clinical Practise Guidelines Management of Dyslipidaemia*, Putrajaya Malaysia.

**35.** Ministry of Health Malaysia 2021. *National Diabetes Registry 2020*.

**36.** Mohamed-Yassin,M.S. Baharudin,N. Daher,A.M. Abu Bakar,N. Ramli,A.S. et al. (2021). High prevalence of dyslipidaemia subtypes and their associated personal and clinical attributes in Malaysian adults: the REDISCOVER study. *BMC Cardiovascular Disorders*, 21(1).

**37.** Mohd-Sidik,S. Lekhraj,R. Foo,C.N. (2021). Prevalence, associated factors and psychological determinants of obesity among adults in Selangor, Malaysia. *International Journal of Environmental Research and Public Health*, 18:1-17.

**38.** National Coordinating Committee on Food and Nutrition. 2010. *Malaysian Dietary Guidelines*, Technical Working Group on Nutritional Guidelines.

**39.** National Institutes of Health (NIH). 2020. National Health and Morbidity Survey (NHMS) 2019: Non-communicable disease, healthcare demand, health literacy - Key Finding.

**40.** Sawada,T. Konomi,A. Yokoi,K. (2020). Serum lipid profiles of young Japanese women with iron deficiency without anemia. *Journal of Trace Elements in Medicine and Biology*, 57.

**41.** Sedodo,N.S. Abosede,O.P. Ilori,O.A. Adenekan,M.K. Idowu,O.M. et al. (2020). Assessment of Fasting Blood Glucose Level of Undergraduates in Abeokuta Ogun State Nigeria. Archives of Current Research International, 42-49.

**42.** Song,Y.H (2014). The association of blood pressure with body mass index and waist circumference in normal weight and overweight adolescents. *Korean Journal of Pediatrics*, 57:79-84.

**43.** Sukkriang,N. Chanprasertpinyo,W. Wattanapisit,A. Punsawad,C. Thamrongrat,N. et al. (2021). Correlation of body visceral fat rating with serum lipid profile and fasting blood sugar in obese adults using a noninvasive machine. *Heliyon*, 7(2).

**44.** Tan,S.T. Mohd-Sidik,S. Rampal,L. Ibrahim,N. Tan,K.A. (2019). Are Malaysians getting fatter and rounder?: An updated systematic review (2009 - 2015). *Malaysian Journal of Medicine and Health Sciences*, 15:63-77.

**45.** Tice,J.R. Cole,L.G. Ungvary,S.M. George,S.D. Oliver,J.A.S. (2019). Clinician accountability in a primary care clinic time-interval blood pressure measurements study: Practice implications. *Applied Nursing Research*, 45(April 2018), 69-72.

**46.** Teh,C.H. Chan,Y.Y. Lim,K.H. Kee,C.C. Lim,K.K. et al. (2015). Association of physical activity with blood pressure and blood glucose among Malaysian adults: A population-based study Chronic Disease epidemiology. BMC Public Health, 15(1).

**47.** TomkinsLane,C.C. Lafave,L.M.Z. Parnell,J.A. Rempel,J. Moriartey,S. et al. (2015). The spinal stenosis pedometer and nutrition lifestyle intervention (SSPANLI): Development and pilot. *Spine Journal*, 15:577-586.

**48.** Vento,K.A. Delgado,F. Lynch,H. (2022). Lipid Profiles of College Female Student-Athletes Participating at Different Competition Levels of Organized Sport. *Frontiers in Sports and Active Living*, 4.

**49.** Wang,H.H. Liao,L.N. Chang,C.W. Chang,Y.C. Wu,K.H. et al. (2019). The alteration of ferritin and transferrin saturation under body mass index and blood pressure in first-time and regular male blood donors in Taiwan. *Medicine (United States)*, 98(22).

**50.** Wang,Y.Y. Zhang,J.X. Tian,T. Gao,M.Y. Zhu,Q.R. et al. (2022). Dietary patterns in association with the risk of elevated blood pressure, lipid profile and fasting plasma glucose among adults in Jiangsu Province of China. *Nutrition, Metabolism and Cardiovascular Diseases*, 32:69-79.

**51.** World Health Organization 2021. *Hypertension*.

**52.** World Health Organization 2011. *Serum ferritin concentrations for assessment of iron status and iron deficiency in populations*.

**53.** Zhu,Y. Chen,G. Bo,Y. Liu,Y. (2019). Markers of iron status, blood pressure and incident hypertension among Chinese adults. *Nutrition, Metabolism and Cardiovascular Diseases*, 29:830-836.

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