Analysis of blood parameters in relation to the risk of cardiovascular disease for older population in Kelantan

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Abstract. Cardiovascular disease (CVD) is known to be the leading cause of morbidity and mortality worldwide and its complication is increasing among older people. Blood parameters including blood pressure (BP), glucose (BG), cholesterol (CHL) and uric acid (UA) are important aspects in maintaining a good condition of the cardiovascular system. The aim of this study is to determine the reference values of blood parameters among older population as well as to assess the association of CVD risk factors with the factors of age, gender and body mass index (BMI). Blood samples were collected from 400 older respondents (≥50 years) in Kota Bharu, Kelantan. The findings showed that respondents aged ≥60 years had significantly higher levels of BP and UA, but lower CHL than 50-59 years respondents (p<0.05). The males had significantly higher BP and lower CHL than the females (p<0.05). The respondents with BMI of ≥25 kgm² had significantly higher BP and BG than the respondents with BMI of <25 kgm² (p<0.05). There were significant associations between BP-BG, BG-UA and CHL-UA. It can be concluded that the levels of blood parameters are affected by the factors of age, gender and BMI.

1. Introduction

Natural changes in the cell due to aging process may slow down or alter the capability of humans. Through the aging process, the bodies start to lose functions where they stimulate the increasing damage at the cellular tissue and molecular levels, leading to the risk of morbidity and of mortality. Ageing is one of the widely recognized risk factors for most human diseases [1]. Chronic diseases such as heart attack, stroke, type-2 diabetes, obesity and cancer are the leading causes of morbidity and mortality in Malaysia. Pursuing this further, based on the health facts by Ministry of Health Malaysia (MoH), the number one principal cause of death in MoH hospitals is the circulatory system disease and likewise the private hospitals.

Hypertension (high BP), hyperglycaemia (high BG), hypercholesterolemia (high CHL) and hyperuricemia (high UA) are commonly associated with the increased risk of cardiovascular death. Hypertension, hyperglycaemia, hypercholesterolemia and hyperuricemia are the risk factors for developing CVD [2]. Hypertension is a long term medical condition where the pressure of the blood in the arteries is perpetually elevated. Long term high blood pressure is usually linked to the complication of the arteries that can lead to the commonly known disease of heart attack or stroke. The disproportionate of glucose levels circulating in the blood plasma can cause harm to the blood vessels and the organs they supply which leading to the complications of diabetes. Diabetes burdens the heart and increases the risk of coronary heart disease [3].

An excessive amount of cholesterol levels in blood is highly associated with the increase in the risk of coronary heart disease [4]. The excess cholesterol in the bloodstream triggers the deposition of cholesterol in the wall of blood vessels, especially coronary arteries that supply blood to the heart, also known as calcification of arteries. The high values of uric acid in blood drive to the deposition of urate crystal that accumulate around or in the joints thus triggering the body’s inflammatory immune response. The inflammation process may lead to the blood clots in the vessels where it contributes to heart attack and stroke [5].

All four risk factors together are the major condition of the circulatory system complications that involve the blockage of the blood vessel to the brain and simultaneously affect the risk for heart disease.
These risk factors can be controlled, treated or modified by changing lifestyles including physical activities and eating habits. Nonetheless, some of the major CVD risk factors are non-modifiable. The aging process, family history and gender are the non-modifiable factors that substantially contribute the development of CVD. A study reported the results finding, among men and women, their differences demonstrated virtually half the risk associated with the CVDs [7]. The differences are notable in hormones, body weight, height, body fat distribution, heart rate, stroke volume, and arterial compliance [8].

This present study would form a baseline data for the assessment of health status among the older adult population as well as reference point for future comparative study for the effects of different factors on the blood parameters. In addition, this study can give early indications about health management towards the respondents and community as a whole, which it can improve individual’s health awareness and hinder the CVD risk factors.

2. Materials and Method

2.1. Setting and Study Population
A total of 400 older adult respondents, aged ranging from 50 to 77 years (mean age: 59.5±7.6 years) agreed to participate in this study. This cohort was examined in the area of Kota Bharu, Kelantan. Appointments were set with the respondents a day prior to the measurements of blood readings. The percentages of males and females participating in this study were 40.3% (n=161) and 59.7% (n=239), respectively. In analysing the data, the respondents were divided into two age groups. Such age groups divided were, range of 50 to 59 years old and 60 years and above. The study population, therefore, was distributed according to the BMI of underweight and normal weight (<25 kgm²) and overweight and obese (≥25 kgm²). Both diagnosed and undiagnosed respondents were chosen to voluntarily participate in the study after explaining the purpose of research and procuring their consent. This study protocol was reviewed and approved by the Medical Research and Ethics Committee of the Ministry of Health Malaysia.

2.2. Study Design and Data Collection
This research was a population-based and cross-sectional study. The questionnaire form was supplied to each respondent given the option either to complete the form themselves or with the guide of study assistance. The inquiries of questionnaire included age, gender, BMI and family history. The BP was firstly measured using Omron Automatic Blood Pressure Monitor while the respondent was in a sitting position, relaxed and without tourniquet or muscle contraction. The BP of the respondents were reported in two readings which were systolic blood pressure (SBP) and diastolic blood pressure (DBP). A lancing device, lancet, cotton wool and an alcohol pad were needed for each respondent to obtain sufficient blood sample (0.5-40.0 µL) to be dropped on BG, CHL and UA test strips inserted into strip slots of Glucosure Autocode Monitoring System, Cardiochek PA Plus Analyzer and MultiSure Uric Acid Meter, respectively. The BMI of the respondents were calculated as weight in kilograms divided by height in meters squared.

2.3. Data Analysis
The recorded data were tabulated and coded on Microsoft Office Excel 2013 and then being transferred to IBM SPSS version 20 software for the process of carrying out the statistical analysis. The significant differences of blood parameters between two groups of each factor were determined using independent samples t-test. The values are expressed as means ± standard deviation. The Pearson’s Correlation Coefficients were used to determine the associations and coefficients between the blood parameters. The Linear Regressions were used to assess the relationship between blood parameters and factors of age and BMI, providing the equations to predict the value of blood parameters from the factors. Binary logistic regression was used to investigate the relationship between the prevalence of hypertension, hyperglycaemia, hypercholesterolemia and hyperuricemia, and, age and BMI.
3. Results

Table 1 represents the mean and standard deviation values for each blood parameter in two groups of each factor. The findings showed that the older age group respondents had statistically significantly higher SBP and UA, but lower CHL than the younger age group respondents (p<0.05). The females had significantly higher CHL and lower DBP than the males (p<0.05). The higher BMI group was found to have significantly greater SBP, DBP and BG than the lower BMI group (p<0.05).

Table 2 shows the correlation coefficients of blood parameters among older adult respondents. The significant association and positive correlation can be seen between SBP and DBP (r=0.597, p<0.01), SBP and MAP (r=0.874, p<0.01), DBP and MAP (r=0.911, p<0.01), SBP and BG (r=0.138, p<0.05), MAP and BG (r=0.113, p<0.05), BG and UA (r=0.114, p<0.05). The significant association and negative correlation were found between CHL and UA (r=-0.188, p<0.01).

Table 3 and Table 4 present the regression equations of blood parameters for the factors of age and BMI, with their respective R² values, for male and females, respectively. The 5th to 95th percentiles values are considered as acceptable minimum to maximum range for the blood parameters at the specific age and BMI.

Table 5 shows the binary analysis between the CVD risk factors and independent factors. Increasing age was significantly associated with an increased likelihood of developing hypertension (OR>1, p<0.05). In terms of gender, the males were significantly 0.37 and 0.43 times less likely to exhibit hypercholesterolemia and hyperuricemia, respectively, than the females (OR<1, p<0.05). A rise in BMI was significantly associated with an incline in likelihood of suffering hypertension and hyperglycaemia (OR>1, p<0.05).

| Blood Parameters | Age Group (years) | Gender | BMI (kgm²) |
|------------------|-------------------|--------|------------|
|                  | 50-59 | ≥60 | Male | Female | <25 | ≥25 |
| SBP (mmHg)       | 132.4±17.7a       | 139.7±19.7a   | 137.1±18.7 | 134.7±19.1 | 132.7±18.8a | 139.6±18.5a   |
| DBP (mmHg)       | 80.8±10.3         | 79.1±12.2     | 81.7±11.9a | 78.9±10.5a | 78.6±11.4a | 82.0±10.7a    |
| BG (mmol/L)      | 7.47±2.94         | 7.76±3.13     | 7.84±2.71  | 7.43±3.22  | 7.13±2.65a | 8.22±3.38a    |
| CHL (mmol/L)     | 5.073±1.395a      | 4.725±1.598a  | 4.690±1.257a| 5.070±1.624a| 5.017±1.576| 4.784±1.378   |
| UA (mg/dL)       | 6.35±1.86a        | 6.83±1.88a    | 6.79±1.87  | 6.41±1.88  | 6.40±1.69  | 6.78±2.10     |

* Indicates the difference between two groups of a factor is significant (p<0.05).

Table 2. Correlation of blood parameters.

| Parameters | SBP | DBP | BG | CHL |
|------------|-----|-----|----|-----|
| DBP        | 0.597a |
| BG         | 0.138b | 0.069 |
| CHL        | 0.086 | 0.081 | -0.095 |
| UA         | 0.015 | -0.014 | 0.114b | -0.188a |

a Correlation is significant at p<0.01.

b Correlation is significant at p<0.05.
Table 3. Regression equations for blood parameters according to age and BMI for males.

| Dependent factor (Y) | Independent factor (X) | Equation                                      | $R^2$ |
|----------------------|------------------------|------------------------------------------------|-------|
| SBP                  | Age                    | 5th percentile: $Y = 0.00001558X^3 - 0.209X + 118.203$ | 0.000 |
|                      |                        | 50th percentile: $Y = -0.059X^2 + 7.500X - 97.510$  | 0.113 |
|                      |                        | 95th percentile: $Y = -0.120X^2 + 15.314X + 341.551$ | 0.140 |
|                      | BMI                    | 5th percentile: $Y = -0.001X^3 - 1.156X + 115.778$  | 0.416 |
|                      |                        | 50th percentile: $Y = 0.004X^2 + 1.358X + 98.805$    | 0.495 |
|                      |                        | 95th percentile: $Y = -0.105X^2 + 6.948X + 54.661$   | 0.221 |
| DBP                  | Age                    | 5th percentile: $Y = -0.004X^2 + 0.136X + 71.346$    | 0.075 |
|                      |                        | 50th percentile: $Y = -0.046X^2 + 5.334X - 71.769$   | 0.312 |
|                      |                        | 95th percentile: $Y = -0.087X^2 + 10.532X - 214.884$ | 0.116 |
|                      | BMI                    | 5th percentile: $Y = -0.002X^3 - 0.070X^2 + 49.906$  | 0.062 |
|                      |                        | 50th percentile: $Y = -0.051X^2 + 3.346X + 30.093$   | 0.448 |
|                      |                        | 95th percentile: $Y = -0.040X^2 + 3.664X + 32.601$   | 0.516 |
| BG                   | Age                    | 5th percentile: $Y = 0.00002300X^3 - 0.002X^2 + 4.555$| 0.363 |
|                      |                        | 50th percentile: $Y = -0.002X^2 + 0.231X + 0.082$    | 0.011 |
|                      |                        | 95th percentile: $Y = -0.00006279X^3 + 0.006X^2 + 5.022$ | 0.020 |
|                      | BMI                    | 5th percentile: $Y = 0.010X^2 - 0.544X + 11.218$     | 0.018 |
|                      |                        | 50th percentile: $Y = -0.019X^2 + 1.107X - 7.858$    | 0.357 |
|                      |                        | 95th percentile: $Y = -0.048X^2 + 2.750X - 26.850$   | 0.231 |
| CHL                  | Age                    | 5th percentile: $Y = -0.00002724X^3 + 0.002X^2 + 0.077$ | 0.054 |
|                      |                        | 50th percentile: $Y = -0.035X + 6.782$               | 0.144 |
|                      |                        | 95th percentile: $Y = -0.019X + 3.967$               | 0.025 |
|                      | BMI                    | 5th percentile: $Y = 0.015X^2 - 0.835X + 14.148$     | 0.212 |
|                      |                        | 50th percentile: $Y = 0.013X^2 - 0.668X + 13.243$    | 0.386 |
|                      |                        | 95th percentile: $Y = 0.011X^2 - 0.502X + 12.342$    | 0.101 |
| UA                   | Age                    | 5th percentile: $Y = -0.00001616X^3 + 0.001X^2 + 2.162$ | 0.004 |
|                      |                        | 50th percentile: $Y = 0.0001764X^3 - 0.213X - 15.521$ | 0.034 |
|                      |                        | 95th percentile: $Y = 0.00084875X^3 - 0.008X^2 + 20.234$ | 0.092 |
|                      | BMI                    | 5th percentile: $Y = -0.103X + 4.731$               | 0.238 |
|                      |                        | 50th percentile: $Y = -0.015X^2 + 0.820X - 4.314$    | 0.290 |
|                      |                        | 95th percentile: $Y = -0.038X^2 + 1.965X - 15.217$   | 0.277 |
Table 4. Regression equations for blood parameters according to age and BMI for females.

| Dependent factor (Y) | Independent factor (X) | Equation | R²  |
|----------------------|------------------------|----------|-----|
| SBP                  | Age                    | 5th percentile: 0.005X² – 5.975X + 265.119 | 0.394 |
|                      |                        | 50th percentile: Y = 0.028X2 – 3.040X + 214.317 | 0.274 |
|                      |                        | 95th percentile: Y = 0.002X² – 0.104X + 163.514 | 0.008 |
|                      | BMI                    | 5th percentile: Y = -0.034X² + 2.729X + 58.639 | 0.248 |
|                      |                        | 50th percentile: Y = -0.109X² + 6.267X + 48.767 | 0.323 |
|                      |                        | 95th percentile: Y = -0.184X² + 9.806X + 39.984 | 0.132 |
| DBP                  | Age                    | 5th percentile: Y = -0.013X² + 1.325X + 31.922 | 0.088 |
|                      |                        | 50th percentile: Y = -0.009X² + 0.927X + 58.937 | 0.269 |
|                      |                        | 95th percentile: Y = -0.006X² + 0.529X – 85.952 | 0.055 |
|                      | BMI                    | 5th percentile: Y = 0.011X² + 0.414X² + 45.272 | 0.534 |
|                      |                        | 50th percentile: Y = -0.035X² + 2.394X + 41.743 | 0.710 |
|                      |                        | 95th percentile: Y = -0.081X² + 4.375X + 38.213 | 0.259 |
| BG                   | Age                    | 5th percentile: Y = 0.007X² – 0.856X + 29.653 | 0.035 |
|                      |                        | 50th percentile: Y = -0.00001464X³ + 0.219X – 2.431 | 0.044 |
|                      |                        | 95th percentile: Y = 0.00002391X³ – 0.297X² + 17.508 | 0.124 |
|                      | BMI                    | 5th percentile: Y = -0.021X² + 1.135X – 11.419 | 0.079 |
|                      |                        | 50th percentile: Y = 0.003X² – 0.088X + 7.534 | 0.117 |
|                      |                        | 95th percentile: Y = 0.027X² - 1.311X + 26.486 | 0.056 |
| CHL                  | Age                    | 5th percentile: Y = 0.013X² – 1.601X + 52.413 | 0.369 |
|                      |                        | 50th percentile: Y = 0.00002391X³ – 0.297X + 17.508 | 0.124 |
|                      |                        | 95th percentile: Y = -0.004X² + 0.468X – 6.545 | 0.038 |
|                      | BMI                    | 5th percentile: Y = 0.001X² – 0.040X + 2.831 | 0.019 |
|                      |                        | 50th percentile: Y = -0.002X² + 0.068X + 4.537 | 0.063 |
|                      |                        | 95th percentile: Y = -0.005X² + 6.243X + 6.243 | 0.152 |
| UA                   | Age                    | 5th percentile: Y = -0.001X² + 0.155X – 3.065 | 0.096 |
|                      |                        | 50th percentile: Y = 0.002X² – 0.219X + 11.248 | 0.360 |
|                      |                        | 95th percentile: Y = 0.005X² – 0.592X + 25.561 | 0.282 |
|                      | BMI                    | 5th percentile: Y = -0.011X² + 0.558X – 3.305 | 0.092 |
|                      |                        | 50th percentile: Y = -0.007X² + 0.421X + 0.540 | 0.120 |
|                      |                        | 95th percentile: Y = -0.004X² + 0.284X + 4.386 | 0.059 |
Table 5. Odds ratio (OR) and 95% confidence intervals (CI) for the association between CVD risk factors and independent factors.

| Independent factor | Hypertension\(^a\) | Hyperglycaemia\(^b\) | Hypercholesterolemia\(^c\) | Hyperuricemia\(^d\) |
|--------------------|---------------------|----------------------|-----------------------------|---------------------|
|                    | OR 95% CI           | OR 95% CI            | OR 95% CI                   | OR 95% CI           |
| Age                | 1.05\(^e\) 1.01,1.08 | 1.02 0.99,1.06       | 0.98 0.94,1.02              | 1.02 0.99,1.05      |
| Gender             | 1.18 0.74,1.88      | 0.84 0.52,1.36       | 0.37 0.20,0.72              | 0.43\(^e\) 0.27,0.68 |
| BMI                | 1.10\(^e\) 1.04,1.16 | 1.08\(^e\) 1.02,1.14 | 0.98 0.92,1.05              | 1.01 0.95,1.06      |

\(^a\) Defined as SBP≥140 mmHg and DBP≥90 mmHg.
\(^b\) Defined as fasting BG≥6.1 mmol/L and post-meal BG≥7.8 mmol/L.
\(^c\) Defined as CHL≥6.2 mmol/l.
\(^d\) Defined as UA(male)≥7.3 mg/dL and UA(female)≥6.1 mg/dL.
\(^e\) Effect of independent factor is significant.

4. Discussion

Examination of the impacts of certain independent factors on BP, BG, CHL and UA have been determined. The distributions of the blood parameters of the studied 400 respondents vary depending on such risk factors as age, gender and BMI. Among this population, the significant part of the relationship between the blood parameters and increased age was presented in SBP and UA. The ≥60 year-old respondents had significantly greater means of SBP and UA than 50-59 year-old respondents. This group was also significantly more vulnerable to the risk of developing hyperglycaemia. Age can be said to be a significant risk factor in the inclination of BP (p<0.05). As age increases, the amount of collagen in the heart increases while elastin decreases and calcification occurs. These alterations contribute to the increase of wall thickness and stiffness [9]. In the process of aging, the SBP linearly increases until the age of 70 or 80 years, the DBP meanwhile only increases until approximately the age of 50 or 60 years, then slightly declines afterward [10]. This statement is in agreement with this study in which the lower age group respondents had higher mean of DBP compared to the older age group respondents, but the difference was not significant (p>0.05).

According to Table 1, the ≥60 year-old respondents had greater mean BG value as compared to the 50-59 year-old respondents, but the difference was not significant. The effect of age on developing hyperglycaemia was also insignificant (p>0.05). In terms of the CHL, the 50-59 year-old respondents had statistically significantly higher mean than the ≥60 year-old respondents (p<0.05). Theoretical speaking, the CHL levels seem to decrease beyond the fifties. This hypothesis is supported by Cabrera et al., suggesting that older people with low levels of CHL were associated with increased mortality [11]. It is possibly expected that as the age increases, there would be the reduction of hepatic synthesis, appetite and food intake. However, this hypothesis remains theoretical and further researches are preferable either to prove or reject it. With respect to the UA level, the mean was found to be significantly higher among the older age group respondents (p<0.05). Similar result was also reported by Das et al. in their study carried out in 2014 [12]. The risk of exhibiting hyperuricaemia appeared to be increasing with age. Nevertheless, the age was not a significant factor for this CVD risk factor (OR>1, p>0.05).

Apropos of gender differences, the DBP mean were relatively found to be significantly higher among the male respondents than the females (p<0.05). In line with the study conducted by Dimkpa et al., the DBP measurements before any movement or exercise in males were somewhat higher than the females (p<0.001) [13]. The low levels of DBP among females might be attributable to differences in sedentary lifestyles and habits, since most of the females were housewives and non-smokers. The males were likely found to be 1.18 times higher than the females in exhibiting the hypertension but the gender was not significant effect on this CVD risk factor. The higher level of BG mean in males and higher risk of developing hyperglycaemia in females were both insignificant (p>0.05). The findings showed the females had statistically significantly higher level of CHL mean and higher risk of having
hypercholesterolemia (p<0.05). Similar findings are also observed in the studies carried out by Marhoum et al. and Gostynski et al. in 2013 and 2004, respectively [14]. The higher rates of hypercholesterolemia in females that generally may be attributed to an increase in CHL associated with menopause either naturally or surgically is related to oestrogen deprivation [15]. The males had higher UA mean than the females, but the difference was not significant (p>0.05). Nonetheless, the gender had the negative effect of increased risk of having hyperuricaemia, indicating that females had higher rates for this CVD risk factor prevalence. Commonly, many studies reported the males were more prevalent to the hyperuricaemia and gout [16], yet this study showed the opposite finding. Hyperuricaemia or gout is often misdiagnosed in females as it is usually seen in males, leading to the delayed diagnosis. It can be said that higher UA levels were greatly associated with menopause [17], since the females were mostly had their menopause or post-menopause at the age beyond fifties. The deterioration of the production of oestrogen hormones in postmenopausal females are associated with the increased risk of having hypericaemia or gout. Oestrogen plays a vital role in protecting females from hyperuricaemia and gout [17].

In respect of BMI factor, the significant part of its association with the blood parameters and CVD risk factors was seen in BP and BG, and, hypertension and hyperglycaemia, respectively. In this study, the higher BMI group was found to have significantly higher mean of SBP and DBP, than the lower BMI group, as suggested by the findings done by Mungreiphy et al. [18]. The relationship between BMI and BP in this study, might be contributed to the lifestyles included dietary salt intakes and physical activity levels. The greater the BMI of the respondent, the higher the risk of having of hypertension (p<0.05). This hypothesis is supported by the study investigated by Tuan et al. in 2009 [19]. It was also found that the higher BMI group were more prevalent to the hyperglycaemia (p<0.05). Gregory et al. had reported the similar finding in their study in 2016 [20]. The BMI however has no significant effect on the levels of CHL and UA as well as their risk factors for CVD.

5. Conclusion
In conclusion, variations between blood parameters among the older adult respondents depend on the factors of age, gender and BMI. The assessment of blood parameters has been acknowledged as valuable aspects for monitoring health status among older adult respondents. Taken all together, therefore, these findings suggested that CVD risk factors become increasingly common with increasing age due to heart weakening leading to subtle physiologic changes. Females were at greater risk of diseases like hypercholesterolemia and hyperuricaemia than males. The higher the BMI, the higher the risk of developing hypertension and hyperglycaemia. It can be concluded that the blood parameters may be affected by the factors of age, gender and BMI. The data of the present study may also be helpful in obtaining standard values of blood parameters among Kelantanese individuals over 50 years old.

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