A Statistical Study on the Association Between Physiological and Clinical Parameters

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***Abstract*—Health variables such as dietary habits, age, obesity, family history, elevated blood lipid, glucose, and blood pressure levels play a significant role in the development and growth of numerous chronic diseases. Thus, this study examined the correlation among multiple health variables including age, gender, body mass index, waist circumference, low-density lipoprotein, high-density lipoprotein, total cholesterol, serum uric acid, glucose, and mean arterial pressure recorded from a total of 111 test subjects. Descriptive statistics were calculated, followed by the analysis utilizing the Pearson correlation coefficient to assess and analyze the correlation between each health parameter to gain an improved understanding of their association. Results showed that waist circumference was one of the important indicators in health deterioration. The findings of this study provided a substantial correlation between various health indicators and their potential influence on an individual's well-being.**

***Keywords*—Pearson correlation, physiological parameters, clinical parameters, risk factor, Malaysian subjects**

I. Introduction

The prevalence of unhealthy lifestyles is on the rise worldwide, resulting in the emergence of non-communicable diseases (NCDs) like type II diabetes, chronic respiratory diseases, and cardiovascular diseases. These conditions contribute to an estimated 41 million deaths annually, representing approximately 74% of global mortality [1]. The alteration in disease trends is significantly impacted by environmental shifts, human behavior, demographic transitions, technological advancements, economic factors, and socio-cultural influences. Despite notable progress in both the avoidance and control of severe illnesses, risk indicators, including dietary habits, blood pressure, age, obesity or body mass index, family history, lack of physical activity, and elevated blood lipid levels, play a significant role in the development and growth of NCDs [2], [3].

According to the World Health Organization (WHO), obesity is characterized by the abnormal or excessive accumulation of body fat, which poses a significant health risk. A body mass index (BMI) equal to or exceeding 30 kg/m^2 is generally considered to indicate obesity [4]. The decrease in physical activity, both in occupational and leisure settings, plays a significant role in the observed rise in obesity rates in recent years [5] .

Hyperlipidemia, also known as dyslipidemia, is a medical condition characterized by abnormally high levels of blood lipids, specifically cholesterol and triglycerides. The issue may arise exclusively from genetic factors, although it is frequently observed as an acquired condition. On the basis of data obtained from a survey conducted by the Centers for Disease Control, involving a sample of 1,492 physicians who deliver ambulatory care in non-governmental settings, hyperlipidemia ranks second in prevalence among the top ten chronic conditions encountered. By contrast, hypertension holds the primary position in this list [6].

Discussed previously are the types of diseases under the NCD. The initial treatment of choice for these diseases is lifestyle modification. Nevertheless, modifying the sedentary lifestyle, restricted physical activity, and excessive caloric intake of this susceptible demographic presents a formidable challenge. Early identification of the potential for disease progression may enhance an individual's productivity and quality of life. Additionally, this approach can alleviate the societal burden of disease and reduce associated healthcare expenditures at a national level [7].

In this study , we investigated and analyzed the correlation among age, gender, BMI, waist circumference (WC), low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol (TC), serum uric acid (SUA), glucose (GLU), and mean arterial pressure (MAP). Furthermore, the correlation among health indicators could help readers understand the potential disease based on the relationship.

II. Materials and Methods

A. Study Population

In this study, a baseline assessment was carried out for each subject to acquire some background information regarding their health and demographic. All the selected subjects were Malaysians, non-smokers, and they were invited for the fasting blood test on the second day after the assessment. A total of 111 subjects (58 males and 53 females), between 19 and 80 years old, participated in this study. This

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study was granted an Ethical Approval from the Research Ethics Board of Universiti Kebangsaan Malaysia with the code UKM PPI/111/8/JEP-2018-161. Informed consent from each subject was acquired prior to the study.

B. Health Parameters

We collected data from a diverse sample of individuals, including those of varying ages, genders, and health conditions. Age, gender, BMI, WC, LDL, HDL, TC, SUA, GLU, and MAP were determined with the aid of standardized measurements and laboratory tests. MAP is defined as the diastolic blood pressure plus one-third of the difference between systolic (SP) and diastolic blood pressure (DP), i.e., MAP = DP + 1/3(SP – DP).

C. Pearson Correlation Analysis

Statistical analysis was conducted in Microsoft Excel. The correlation of the parameters in the study group was analyzed using the Pearson correlation coefficient (r method) to provide insight into the direction and strength of relationship between each of them. The r-value was computed and represented in a matrix form with the range of −1 to 1.

A positive r-value would indicate the presence of a positive correlation, where both variables would exhibit a tendency to increase or decrease together. A negative r-value would indicate the presence of a negative correlation, suggesting that as one variable increases, the other variable decreases, or vice versa [8].

III. Results

The male and female groups needed to be separated because of significant differences in the mean WC and SUA. Each gender group was further divided according to their age range of 19–39, 40–59, and 60–80 years old.

The 19–39 year-old age group for male subjects showed dispersion of SUA (SD = 106.2). The female subject under the same age group had a dispersion of 68.4 µmol/L. Similar to male and female subjects from a previous age group, SUA showed the most significant dispersion among all parameters for the age range of 40–59 years old. The SD of SUA among male subjects was 79, whereas that among female subjects was 81.6. For the last age group of 60–80 years old, SUA was the prominent parameter among males, with a dispersion of 108.4 µmol/L in contrast to (SD = 138.9) among females.

Variance for SUA and WC was calculated by squaring the SD for the age groups of 19–39 and 40–59 years old in both genders. Given that the number of subjects in the age group 60–80 years old for both genders was small and not significant, it was omitted from the calculation of variance. The variances for male subjects aged 19–39 years were SUA=11288.2 and WC=327.5, whereas those for male subjects aged 40–59 years were SUA=6236 and WC=98.4. The variances observed in female subjects aged 19–39 years were 4682.1 for SUA and 169.5 for WC. By contrast, male subjects aged 40–59 years exhibited higher variances of 6655.4 for SUA and 172.2 for WC. Considering that all the subjects demonstrated unequal variance and different sample sizes, we proceeded with the Welsh t-test.

The p-values for SUA and WC were calculated by comparing the value of the same health parameter between males and females in the same age group. The p-values for each age group were as follows: (i) 19–39 years old: SUA= 1.81E-10, WC=0.02367; (ii) 40–59 years old: SUA= 0.00022. WC=0.00446. As the p value for age between two independent groups was less than $p<0.05$, statistically significant differences were noted for both genders in terms of WC and SUA. Thus, we suggested the separation of both categories.

TABLE I. demonstrates the numerical data of the male subjects (n=33) aged 16–39 years. 0 presents the data of male subjects (n=21) aged 40–59 years, and 0 illustrates the data of male subjects (n=4) for the age group 60–80 years old.

TABLE I. Descriptive Analysis of The Subjects (Male) for 19-39 Years Old

	Mean	Median	Stdev	Min	Max
Age	29.8	30	6.3	19	39
BMI (kg/m^2)	26.9	26.9	5.7	15.2	39.6
WC (cm)	90.8	90	18.1	32	126
LDL (mmol/L)	3.6	3.6	0.7	2.3	5.0
HDL (mmol/L)	1.3	1.2	0.6	0.7	4.4
TC (mmol/L)	5.5	5.3	0.9	4	7.5
TC/HDL	4.8	4.8	1.4	1.2	7.4
SUA (µmol/L)	446.7	410	106.2	210	651.2
Glucose (mmol/L)	4.9	4.8	0.5	4.2	5.9
MAP (mmHg)	97.8	96	15.0	73.5	140.5

TABLE II. Descriptive Analysis of The Subjects (Male) for 40-59 Years Old

	Mean	Median	Stdev	Min	Max
Age	47.2	45	5.9	40	57
BMI (kg/m^2)	28.9	28.5	3.9	23.5	38.9
WC (cm)	99.9	103	9.9	80.0	115
LDL (mmol/L)	3.4	3.7	1.1	1.2	5.3
HDL (mmol/L)	1.2	1.2	0.1	0.8	1.4
TC (mmol/L)	5.4	5.4	1.3	2.9	7.6
TC/HDL	4.5	4.5	1	2.4	6.3
SUA (µmol/L)	441.2	430	79	230	570
Glucose (mmol/L)	5.7	5.03	2.2	3.2	14.2
MAP (mmHg)	108.0	98.5	26.3	78	175.5

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TABLE III. DESCRIPTIVE ANALYSIS OF THE SUBJECTS (MALE) FOR 60-80 YEARS OLD

	Mean	Median	Stdev	Min	Max
Age	68	67.5	9.8	57	80
BMI (kg/m^2)	27.1	27.1	2.9	24.3	30.1
WC (cm)	91.3	92.5	13.5	76	104
LDL (mmol/L)	2.8	2.6	1	2	4.1
HDL (mmol/L)	1.3	1.2	0.4	1	1.9
TC (mmol/L)	4.7	4.3	0.9	4.1	6
TC/HDL	3.8	4	1.3	2.1	5.2
SUA (µmol/L)	440.6	435.2	108.4	339.1	553
Glucose (mmol/L)	7.3	6.2	2.8	5.4	11.5
MAP (mmHg)	99.3	98.3	5.7	93.5	107

TABLE IV. demonstrates the numerical descriptive data of the female subjects (n=37) for the age group 16–39 years old. TABLE V. indicates the data of female subjects (n=13) for the age group 40–59 years old, and TABLE VI. illustrates the female (n=3) for age group 60-80 years old.

TABLE IV. DESCRIPTIVE ANALYSIS OF THE SUBJECTS (FEMALE) FOR 19-39 YEARS OLD

	Mean	Median	Stdev	Min	Max
Age	27.1	26	5.5	19	39
BMI (kg/m^2)	26.0	23.9	7.3	16.2	46.9
WC (cm)	83.1	80	13	62.5	119
LDL (mmol/L)	2.9	3	0.7	1.7	4.5
HDL (mmol/L)	1.5	1.5	0.3	0.9	2.7
TC (mmol/L)	4.7	4.7	0.7	3.5	6.2
TC/HDL	3.4	3.4	0.9	1.9	6.2
SUA (µmol/L)	281.1	280	68.4	170	440
Glucose (mmol/L)	4.9	4.8	0.6	4.0	7.4
MAP (mmHg)	96.8	96.5	16.3	73.5	151.5

TABLE V. DESCRIPTIVE ANALYSIS OF THE SUBJECTS (FEMALE) FOR 40-59 YEARS OLD

	Mean	Median	Stdev	Min	Max
Age	48.6	50	6.2	40	57
BMI (kg/m^2)	26.7	25.9	4.4	20.7	35
WC (cm)	87.6	81.5	13.1	72.5	113
LDL (mmol/L)	3.4	3.5	0.9	1.8	4.6
HDL (mmol/L)	1.6	1.6	0.3	1.2	2.2
TC (mmol/L)	5.5	5.6	1	3.8	7.1
TC/HDL	3.6	3.3	0.7	2.9	5.2
SUA (µmol/L)	315.5	290	81.6	220.0	452
Glucose (mmol/L)	5	4.9	0.6	4.3	6.5
MAP (mmHg)	107.5	102.5	15	92.5	146.5

TABLE VI. DESCRIPTIVE ANALYSIS OF THE SUBJECTS (FEMALE) FOR 60-80 YEARS OLD

	Mean	Median	Stdev	Min	Max
Age	68	64	7.8	63	77
BMI (kg/m^2)	30.3	30.7	2.0	28.1	32
WC (cm)	102	101	1.7	101	104
LDL (mmol/L)	2.7	3.3	1.1	1.4	3.5
HDL (mmol/L)	1.7	1.6	0.2	1.5	1.9
TC (mmol/L)	5	5.4	1.2	3.6	6
TC/HDL	3	3.2	0.5	2.4	3.3
SUA (µmol/L)	401.1	380	138.9	274	549.4
Glucose (mmol/L)	6	5.2	1.6	5	7.9
MAP (mmHg)	109.3	119	20.8	85.5	123.5

TABLE VII. shows the calculated Pearson correlation coefficient (r) among multiple pairs of parameters for male participants in the age group of 19–39 years old (n=33). 0and TABLE IX. represent the age groups of 40–59 and 60–80 years old, which comprised n=21 and n=4 male subjects, respectively. The r-value is presented in a three-color scale, whereby | r | > 0.70 is in red, | r | > 0.4 is in yellow, and | r | > 0.25 is in green, thereby indicating the correlation level between each variable.

The correlation coefficient matrix featured in TABLE X. illustrates the r-value gained from female subjects (n=37) with the same color coding. TABLE XI displays the r coefficient for subjects n=13 within the age group of 40–59 years old. In 0, a total of n=3 older subjects aged 60–80 years is presented. Several significant correlations were identified as shown in all the tables.

TABLE VII. PEARSON CORRELATION VALUE MATRIX ON THE CORRELATION BETWEEN TWO PARAMETERS (MALE) FOR 19-39 YEARS OLD

	Age	*BMI*	*WC*	*LDL*	*HDL*	*TC*	*TC/HDL*	*SUA*	*GLU*	*MAP*
Age										
BMI	0.18									
WC	0.25	0.84								
LDL	-0.02	-0.04	-0.07							
HDL	0.11	-0.16	0.03	0.01						
TC	-0.03	-0.11	-0.13	0.89	0.08					
TC/HDL	0.02	0.35	0.20	0.51	-0.71	0.41				
SUA	0.11	0.48	0.42	0.09	-0.05	0.06	0.22			
GLU	0.06	0.28	0.19	-0.18	0.16	-0.10	0.06	0.05		
MAP	0.16	0.07	0.04	0.07	-0.17	0.11	0.32	-0.05	0.46	

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TABLE VIII. PEARSON CORRELATION VALUE MATRIX ON THE CORRELATION BETWEEN TWO PARAMETERS (MALE) FOR 40-59 YEARS OLD

	Age	*BMI*	*WC*	*LDL*	*HDL*	*TC*	*TC/HDL*	*SUA*	*GLU*	*MAP*
Age										
BMI	0.38									
WC	0.47	0.83								
LDL	-0.13	-0.37	-0.41							
HDL	-0.22	-0.34	-0.51	0.26						
TC	-0.13	-0.31	-0.40	0.97	0.37					
TC/HDL	-0.06	-0.14	-0.14	0.89	-0.12	0.87				
SUA	0.26	-0.09	0.01	0.17	0.06	0.25	0.22			
GLU	0.03	0.32	0.29	0.07	-0.17	0.05	0.18	-0.20		
MAP	0.44	0.07	0.22	-0.31	-0.58	-0.41	-0.16	-0.05	0.02	

TABLE IX. PEARSON CORRELATION VALUE MATRIX ON THE CORRELATION BETWEEN TWO PARAMETERS (MALE) FOR 60-80 YEARS OLD

	Age	*BMI*	*WC*	*LDL*	*HDL*	*TC*	*TC/HDL*	*SUA*	*GLU*	*MAP*
Age										
BMI	-0.05									
WC	-0.56	-0.07								
LDL	-0.28	-0.90	0.00							
HDL	0.64	0.58	-0.80	-0.60						
TC	-0.27	-0.75	-0.26	0.95	-0.36					
TC/HDL	-0.47	-0.85	0.41	0.91	-0.87	0.76				
SUA	-0.08	-0.95	0.37	0.80	-0.77	0.58	0.90			
GLU	-0.69	0.70	0.56	-0.50	-0.17	-0.50	-0.24	-0.49		
MAP	0.68	0.70	-0.44	-0.86	0.88	-0.75	-0.96	-0.75	0.03	

For male subjects aged 19–39 and 40–59 years, WC (r=0.84) and BMI (r=0.83) displayed a positive correlation, revealing that as the WC increases, the BMI will likely to increase too. Similarly, this trend was also observed among the female subjects within the age groups of 19–39 and 40–59 years, as the WC (r=0.89) and BMI (r=0.77) showed a positive correlation. Older subjects aged 60–80 years for both males (r=0.7) and females (r=0.98) exhibited a positive correlation between BMI and MAP. Correlations between LDL, HDL, TC and TC/HDL are not taken into consideration as the are somehow the same parameters shown in a different way.

Male subjects aged 19–39 years had a positive correlation on SUA with BMI (r=0.48) and WC (r=0.42), suggesting that high SUA levels are associated with high BMI and WC. MAP and GLU showed a positive correlation of r=0.46. GLU and BMI had a positive relation of r=0.28, whereas TC/HDL and BMI had a positive relation of r=0.35).

For males aged 40–59 years, a positive correlation between BMI and GLU (r=0.32) was observed, which indicated that a rise in BMI is likely to result in an increase in insulin level. For the same group, GLU had a positive connection with WC at r=0.29. This result suggested that high GLU levels are connected with large WC.

Elder male subjects tend to exhibit a positive association between their SUA and their TC/HDL ratio (r=0.9). The BMI was shown to have a positive association with both the GLU and the MAP, with an identical r-value of 0.7. The correlation from GLU to WC was r=0.56. TC/HDL and WC had a correlation of 0.41, whereas SUA and WC had a correlation of 0.37.

A positive association was observed between MAP and GLU, with a value of 0.62, for women between the ages of 19 and 39 years. In SUA, a favorable connection was noted among TC/HDL (r = 0.57), BMI (r = 0.47), and WC (r = 0.49). A positive correlation may exist between GLU and BMI, between GLU and WC, and between GLU and SUA, with the relevant correlation coefficients being 0.47, 0.38, and 0.56, respectively.

A significant positive association of r=0.61 was found between the health indicators of SUA and WC for women in the middle age range (40–59 years old). SUA and BMI were correlated, with an r-value of 0.38. Both SUA and WC exhibited a connection with GLU, with r=0.51 and r=0.35, respectively, demonstrating that a relationship existed among the three variables.

For women of advanced age, GLU exhibited a positive association that was identical to a perfect one (r = 1). MAP showed a positive association with BMI, with r = 0.98. Both TC/HDL ratio (r=0.73) and BMI (r=0.45) showed a positive connection with SUA. MAP and WC revealed a correlation of r=0.4, and MAP and GLU had a correlation of r=0.34

TABLE X. PEARSON CORRELATION VALUE MATRIX ON THE CORRELATION BETWEEN TWO PARAMETERS (FEMALE) FOR 19-39 YEARS OLD

	Age	*BMI*	*WC*	*LDL*	*HDL*	*TC*	*TC/HDL*	*SUA*	*GLU*	*MAP*
Age										
BMI	0.13									
WC	0.18	0.89								
LDL	0.08	0.45	0.51							
HDL	-0.15	-0.50	-0.48	-0.34						
TC	-0.03	0.25	0.33	0.89	0.08					
TC/HDL	0.00	0.53	0.57	0.78	-0.77	0.52				
SUA	0.02	0.47	0.49	0.35	-0.48	0.21	0.57			
GLU	0.27	0.47	0.38	0.31	-0.21	0.29	0.36	0.56		
MAP	0.23	0.36	0.23	0.14	-0.01	0.19	0.13	0.41	0.62	

TABLE XI. PEARSON CORRELATION VALUE MATRIX ON THE CORRELATION BETWEEN TWO PARAMETERS (FEMALE) FOR 40-59 YEARS OLD

	Age	*BMI*	*WC*	*LDL*	*HDL*	*TC*	*TC/HDL*	*SUA*	*GLU*	*MAP*
Age										
BMI	0.43									
WC	0.48	0.77								
LDL	-0.07	-0.41	-0.41							
HDL	-0.28	-0.01	-0.22	0.55						
TC	-0.07	-0.33	-0.31	0.97	0.67					
TC/HDL	0.24	-0.46	-0.13	0.43	-0.50	0.30				
SUA	0.54	0.38	0.61	-0.67	-0.37	-0.56	-0.18			
GLU	0.15	0.19	0.35	-0.51	-0.48	-0.43	0.08	0.51		
MAP	0.21	-0.05	-0.09	0.24	0.04	0.23	0.15	-0.27	-0.04	

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TABLE XII. PEARSON CORRELATION VALUE MATRIX ON THE CORRELATION BETWEEN TWO PARAMETERS (FEMALE) FOR 40-59 YEARS OLD

	Age	*BMI*	*WC*	*LDL*	*HDL*	*TC*	*TC/HDL*	*SUA*	*GLU*	*MAP*
Age										
BMI	0.13									
WC	1.00	0.19								
LDL	-1.00	-0.11	-1.00							
HDL	-0.79	0.51	-0.75	0.80						
TC	-0.99	0.04	-0.97	0.99	0.88					
TC/HDL	-0.99	-0.29	-0.99	0.98	0.68	0.94				
SUA	-0.83	0.45	-0.79	0.84	1.00	0.91	0.73			
GLU	1.00	0.12	1.00	-1.00	-0.79	-0.99	-0.98	-0.83		
MAP	0.34	0.98	0.40	-0.33	0.30	-0.18	-0.49	0.24	0.34	

IV. DISCUSSION

Significant correlations were observed among age, BMI, WC, TC, LDL, HDL, SUA, GLU, and MAP for male and female subjects.

In male subjects, BMI (r=0.84) and WC (r=0.83) displayed a strong positive correlation for the age groups 19–39 and 40–59 years old, respectively, indicating that high BMI was associated with an increase in WC. The loss of a significant amount of muscle mass results in an increase in WC as the abdominal muscles lose elasticity. In older people above 60 years old, BMI was positively correlated with MAP (r=0.7). As an individual ages, they tend to be inactive because of their weakened body. The body cannot burn the excess fat, which causes inflammation and insulin resistance, eventually leading to hypertension.

Similar to male subjects, female subjects showed a positive correlation between BMI and WC for the age groups 19–39 and 40–59 years old, with r=0.89 and r=0.77, respectively. Thus, BMI and WC are not gender-based health parameters but based on an individual's lifestyle that contributes to the increase in BMI and WC. Female subjects in the age group of 60–80 years showed four pairs of correlation (r = 1), indicating perfect positive correlation. GLU is a good indicator for WC in aging subjects because both parameters had r=1. We observed high MAP due to high BMI among female subjects above 60 years old. According to [9], the observed phenomenon of elevated MAP can be attributed to a decrease in DP and an increase in SP.

Obesity is assessed through WC and BMI, indicating a positive correlation between the variables. Obesity burdens the body and is responsible for the increase in resistance of muscle and tissue cells to insulin and excess production of GLU by liver. The secretion of uric acid from adipose tissue in individuals with obesity was found to be elevated as excessive accumulation of fat in the body can lead to the production and secretion of uric acid [10]. Abnormal levels of TC in the human body indicate elevated concentrations of LDL [11]. Obesity decreases good cholesterol also known as HDL.

V. CONCLUSION

This study utilized the Pearson correlation coefficient (r) to test and explore the relationships among age, gender, and other health parameters recorded from 111 Malaysian subjects. The results of this study demonstrated an overview on the association between each health parameter and the potential consequences to an individual's health. Waist circumference (WC) was shown to be a good indicator for the NCD risk factor. The authors believe that the results of this work will help medical authorities access the relevancy of each health indicator in reducing and managing diseases related to the variables. Further comprehensive studies should be conducted to ascertain the specific effect of individual health parameters in mitigating adverse outcomes.

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