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High Density Lipoprotein Cholesterol Predicts Triglycerides Level in Three Distinct Phases of Blood Pressure

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Abstract

Atherosclerosis is also known as arteriosclerotic vascular disease. It is a condition when the arteries become narrowed and hardened due to the excessive of plaque which is made of fat, cholesterol, calcium and other substances. This study aims to examine the regulatory roles of triglycerides level in three distinct phases of blood pressure. One way ANOVA analysis is used to test the differences among the three distinct conditions, which is normal, borderline and hypertensive. The systolic blood pressure highly significant different (F (2, 997) = 3.595, p = 0.028) across the three distinct phases. We also applied multiple linear regression (MLR) method in order to assess the associated factor of triglycerides level according to the three distinct phases as discussed in ANOVA analysis. The statistical analyses revealed that there are partially significant differences due to the different distinct phases of blood pressure. The associated factors of triglycerides were total of cholesterol, high density lipoprotein cholesterol and proconvertin. All the variables were statistically significant across the three main conditions. These initial findings from three distinct phases denote that there a negative association between triglycerides level and HDL cholesterol. This finding shows that the factor of triglycerides level might be a valuable marker of atherosclerosis in three distinct phases of blood pressure.

Keywords: Triglycerides; ANOVA; Normal, Borderline and Hypertensive blood pressure; Multiple linear regression

1. introduction

The cardiovascular disease especially in hypertension patients not only increases the risk of cardiovascular but it also increases the risk of atherosclerosis [1]. In epidemiologic studies, the hypertension plays the role as the one of the risk factors of atherosclerosis but still controversial and complex [1, 12]. This increased risk might be attributed to the heart attack, stroke, peripheral arterial disease, erectile dysfunction and kidney disease [16].

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The low HDL cholesterol and high triglycerides level was one of the factors which attributed to the pathogenesis coronary artery disease [17]. Besides that, HDL cholesterol also helps to prevent the atherosclerotic cardiovascular complication by scavenges and removes LDL or bad cholesterol and act as a maintenance function for the inner walls of blood vessel [15, 18]. A strong association between triglycerides and HDL-cholesterol level might exist in three distinct phases of blood pressure which normal, borderline and hypertensive. This study aims to examine the regulatory roles of triglycerides level in three distinct phases of blood pressure.

1.1. Materials and methods

The participants are patient diagnosed clinically with triglycerides and HDL-Cholesterol with three distinct phases of normal, borderline and hypertensive among blood pressure patients between 1st January 2009 and 31st December 2011. A total of 1000 registered patients from Hospital University Sains Malaysia (HUSM) were screened and met the inclusion and exclusion criteria (Table 1). The description of the variables also can be seen in the Table 3.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
a) From Malay population	a) Breast feeding or pregnant women
b) Blood pressure is divided to normal (<120), borderline (120-139) and hypertension (>140)	b) The presence of chronic disease such as kidney disease, liver disease and serious injuries
c) Any other condition which recommend by the physician	c) Any other condition which not recommended by the physician

The main outcome evaluated is the association of the triglyceride level which was evaluated by using multiple linear regression analysis. All subjects were assigned to blood pressure level categories which are systolic blood pressure level which are normal, borderline and hypertensive. Normal systolic blood pressure classification is less than 120 mmHg, borderline is 120-139 mmHg and hypertensive is more than 140 mmHg [9]. Power and Sample Size Calculation (PS) software are used to calculate sample size of the analysis with significance level (α) 0.05 and the power of the study $(1-\beta)$ of 80% [10, 11, 14, 20]. Parameter involved:

- Type 1 Error = 5.0%
- Power = 80.0%
- M = 1
- P_0 = Based on literature review
- P_1 = Based on Expert Opinion

The largest size sample was taken to start the analysis. From the Table 2, we choose n = 161 patients. One way analysis of variance (ANOVA) method were used to evaluate the triglycerides level which to test the for preferences differences among the three distinct phases of blood pressure. Multiple linear regression analysis with enter method was applied to serum triglyceride level at three distinct phases of systolic blood pressure. Two-tailed values of *p* were considered statistically significant which set at level 0.05. SPSS software version 15.0 was used to analyzed data and for all statistical calculations.

Table 2. Sample Size Calculation

No. Variables	*P_1	P_o	M	Type 1 error	Power	Sample Size
Systolic blood pressure [18]	0.29	0.16	1	5%	80%	161
Diastolic blood pressure [18]	0.23	0.11	1	5%	80%	153
HDL-Cholesterol [18]	0.51	0.35	1	5%	80%	149
Hypertension [19]	0.54	0.38	1	5%	80%	151

Table 3. Description of the variables

Variables	Description
Height	Height (cm)
Bmi	Body mass index of patients (weight(kg)/[height(m)]^2)
Weight	Weight (kg)
Kcal	Kilo-calories of physical activity per week
Smoke	Smoking status (0 = no, 1= yes)
Pkyrs	Pack per years of smoking
Wc	Waist circumference of patients (cm)
Hip	Hip circumference (cm)
Sbp	Systolic blood pressure of patients (mmHg)
Dbp	Diastolic blood pressure of patients (mmHg)
Triglycerides	Triglycerides level of patients (mg/dl)
Cholesterol	Total cholesterol of patients (mg/dl)
HDL-Cholesterol	High density lipoprotein cholesterol (mg/dl)
Glucose	Glucose level of patients (mg/dl)
Proconvertin	Proconvertin (%)
Fib	Fibrinogen (mg/dl)
Fhha	Family history of heart attack (0 = no, 1= yes)
Diabetes	Diabetes status (0 = no, 1= yes)
Inccd	Incident (new) CHD during 6 years of follow-up (0 = no, 1= yes)
Insulin	Insulin level of patients (IU/ml)
Taking anti-hypertensive medication	Taking anti-hypertensive medications (0 = no, 1= yes)
Taking lipid lowering medication	Taking lipid lowering medication (0 = no, 1= yes)

Table 4. Clinical, Lifestyle and other characteristics according to Systolic Pressure level: normal borderline and hypertensive

Variables	< 120 mm Hg, *n* = 232 Mean (SD)	120 – 139 mm Hg, *n* = 364 Mean (SD)	> 140 mm Hg, *n* = 398 Mean (SD)
Basic Data			
Height	174.03 (6.16)	174.0 (6.56)	172.46 (6.28)
Body Mass Index	25.96 (3.80)	26.54 (3.52)	26.69 (3.76)
Weight	48.71 (12.28)	50.48 (11.80)	49.58 (12.85)
Lifestyle Factors			
Kilo-calories of physical activity per week	2071.8 (2035.6)	2235.7 (2405.8)	1957.16(2015.3)
Smoking status	0.09 (0.284)	0.13 (0.33)	0.103 (0.304)
Pack years of smoking	24.58 (31.37)	24.33 (27.90)	26.88 (33.30)
Waist circumference	96.49 (10.05)	97.84 (10.07)	98.43 (10.50)
Hip circumference	100.7 (6.82)	101.55 (6.98)	101.53 (7.98)
Clinical factor			
Systolic blood pressure	110.42 (7.7)	129.56 (5.79)	157.73 (14.46)
Diastolic systolic pressure	64.07 (8.51)	71.50 (8.67)	78.82 (10.50)
Lipids			
Triglycerides	129.77 (64.82)	142.71(76.44)	147.30 (91.92)
Total cholesterol	199.36 (39.52)	198.36 (35.09)	199.97 (34.58)
HDL cholesterol	47.95 (11.71)	47.28 (12.05)	48.84 (13.58)
Biochemical			
Glucose	105.17 (18.17)	109.25 (30.16)	115.93 (36.46)
Proconvertin	110.26 (22.29)	114.0 (22.31)	117.68 (26.78)
Fibrinogen	312.83 (61.54)	315.27 (67.98)	321.31 (66.22)
Diseases			
Family history of heart attack	0.28 (0.451)	0.30 (0.461)	0.31 (0.462)
Diabetes	0.239 (0.428)	0.31 (0.46)	0.372(0.48)

Incident coronary heart disease	0.14 (0.351)	0.14 (0.348)	0.25 (0.44)
Medication			
Serum Insulin	16.11 (26.75)	15.98 (13.85)	17.52 (29.04)
Taking anti-hypertensive medication	0.24 (0.430)	0.33 (0.472)	0.44 (0.50)
Taking lipid lowering medication	0.03 (0.17)	0.04 (0.20)	0.03 (0.17)

*Note: Significant levels: **p < 0.01, *p < 0.05*

1.2. Results

The risk factors characteristics according to level systolic blood pressure in normal, borderline and hypertensive are summarized in Table 4. Patients with higher systolic blood pressure tended to have higher triglycerides level and slightly higher of HDL-cholesterol but total cholesterol with slightly decrease as the higher systolic blood pressure. They also had a higher intake of smoking pack per year; they were less physically active and also the smoker increase as the higher systolic blood pressure. They also tended to have a slightly low of body mass index, height and weight as the systolic blood pressure increases.

Besides that, they also tended to higher waist and hip circumference, a higher systolic blood pressure and diastolic blood pressure. Furthermore, they also tended to a higher glucose, a higher proconvertin and a higher fibrinogen as the systolic blood pressure increases. They also tended to increase in incident coronary heart disease, family history of heart attack and diabetes as the high of systolic blood pressure. They also tended to take serum insulin and anti-hypertensive medication as the high systolic blood pressure. The taking lipid medication slightly increases and slightly decreases as the high systolic blood pressure.

Table 5 shows the preferences for the systolic blood pressure differed significantly (F (2, 997) = 3.595, p = 0.028) across the three distinct phases normal, borderline and hypertensive. There are several comparisons systolic blood pressure phases listed in the Table 6. In the first row and second row, we can see the comparison between normal systolic blood pressure with borderline and normal with hypertensive systolic blood pressure. The mean difference between the two groups of systolic blood pressure is 12.945 and 17.528. Following this row across, we see that this differences was not statistically significant (p = 0.163) followed by the second row which is statistically significant (p = 0.024). In the third row, comparison of borderline systolic blood pressure with hypertensive. The mean differences between these groups are 4.582. Following this row across, we also see that this differences was not statistically significant (p = 1.000). In the Table 6 above, we see that the significant overall ANOVA we found earlier was due to differences between just two groups: normal versus hypertensive. None of the other comparisons are significant.

Table 5. Results of one-way ANOVA analysis

Groups	Sum of squares	Df	Mean square	F	Sig.
Between groups	46660.560	2	23330.280	3.595	0.028*
Within groups	6471061.591	997	6490.533		
Total	6517722.151	999			

*Notes: Dependent variable: Serum triglycerides level; Factors: Systolic blood pressure; *Significant at the 0.05 percent level.*

Table 6. Multiple Comparisons (Post Hoc Tests)

Systolic Blood Pressure	Systolic Blood Pressure	Mean Difference (I-J)	Std. Error	Sig.
Normal	Borderline	-12.945	6.716	0.163
	Hypertensive	-17.528*	6.601	0.024
Borderline	Normal	12.945	6.716	0.163
	Hypertensive	4.582	5.843	1.000
Hypertensive	Normal	17.528*	6.601	0.024
	Borderline	4.582	5.843	1.000

Table 7 shows the variables in the final model of multiple linear regression for normal blood pressure phases on triglycerides levels (mg/dl). The main factor which associated with triglycerides level were height, body mass index, hip circumference, total cholesterol, HDL cholesterol, proconvertin and incident coronary heart disease. It is clearly observed from the results that height (β = 1.639, 95% CL = 0.640, 2.731 p-value < 0.01), body mass index (β = 10.752, 95% CL = 5.235, 16.269 p-value < 0.01), total cholesterol (β = 0.420, 95% CL = 0.227, 0.614 p-value < 0.01), proconvertin (β = 0.572, 95% CL = 0.241, 0.904 p-value < 0.01), were positively associated with triglycerides level. Hip circumference (β = -4.151, 95% CL = -6.335, -1.968 p-value < 0.01), HDL cholesterol (β = -2.373, 95% CL = -3.018, -1.797 p-value < 0.01), incident coronary heart disease (β = -21.820, 95% CL = -41.567, -2.072 p-value < 0.05), has been negatively associated with the triglycerides level.

Table 8 shows the variables in the final model of multiple linear regression for borderline blood pressure phases on triglycerides levels (mg/dl). The main factor which associated with triglycerides level was weight, waist circumference, total cholesterol, HDL cholesterol, glucose and proconvertin. It is clearly observed from the results that waist circumference (β = 1.524, 95% CL = 0.190, 2.858 p-value < 0.05), total cholesterol (β = 0.248, 95% CL = 0.068, 0.428 p-value < 0.01), glucose (β = 0.561, 95% CL = 0.281, 0.841 p-value < 0.01), proconvertin (β = 1.123, 95% CL = 0.842, 1.403 p-value < 0.01), serum insulin (β = 0.580, 95% CL = 0.095, 1.065 p-value < 0.05), taking lipid lowering medication (β = 0.580, 95% CL = 0.095, 1.065 p-value < 0.05), were positively associated with triglycerides level. Weight (β = -1.261, 95% CL = -2.417, -0.104 p-value < 0.05) and HDL cholesterol (β = -2.805, 95% CL = -3.337, -2.273 p-value < 0.01), were negatively associated with the triglycerides level.

Table 7. Model of associated factor for Triglycerides by Multiple Linear Regression (MLR) for Normal phases of blood pressure

Variable	Std. Coefficient Beta (β)	95.0% Confidence Interval For B		p-value
		Lower	Upper	
Basic Data				
Height	1.639**	0.640	2.731	0.001
Body Mass Index	10.752**	5.235	16.269	0.000
Weight	-0.566	-1.840	0.707	0.382
Lifestyle Factors				
Kilo-calories of physical activity per week	-0.001	-0.005	0.002	0.479
Smoking status	6.253	-18.715	31.222	0.622
Pack years of smoking	0.032	-0.203	0.266	0.791
Waist circumference	-0.401	-1.973	1.171	0.616
Hip circumference	-4.151**	-6.335	-1.968	0.000
Clinical factors				
Systolic blood pressure	0.328	-0.575	1.231	0.475
Diastolic systolic pressure	-0.513	-1.355	0.330	0.232
Lipid				
Total cholesterol	0.420**	0.227	0.614	0.000
HDL cholesterol	-2.373**	-3.018	-1.797	0.000
Biochemical				
Glucose	0.321	-0.343	0.986	0.342
Proconvertin	0.572**	0.241	0.904	0.001
Fibrinogen	-0.053	-0.166	0.060	0.357
Diseases				
Family history of heart attack	-9.923	-25.452	5.606	0.209
Diabetes	6.740	-31.356	44.836	0.728
Incident coronary heart disease	-21.820*	-41.567	-2.072	0.031
Medication				
Serum Insulin	0.037	-0.239	0.313	0.794
Taking anti-hypertensive medication	11.924	-4.637	28.486	0.157
Taking lipid lowering medication	-35.963	-76.617	4.691	0.083
R^2		0.888		
Adjust R^2		0.877		
Durbin-Watson		1.867		

*Note: Significant levels: **p < 0.01, *p < 0.05*

Table 9 shows the variables in the final model of multiple linear regression for hypertension blood pressure phases on triglycerides levels (mg/dl). The main factor which associated with triglycerides level was total cholesterol, HDL cholesterol, proconvertin, serum insulin and taking anti-hypertensive drug. It is clearly observed from the results that total cholesterol (β = 0.577, 95% CL = 0.346, 0.807 p-value < 0.01), proconvertin (β = 0.842, 95% CL = 0.546, 1.139 p-value < 0.01), serum insulin (β = 0.475, 95% CL = 0.200, 0.750 p-value < 0.01), taking anti-hypertensive drug (β = 15.704, 95% CL = 0.111, 31.297 p-value < 0.05), were positively associated with triglycerides level. HDL cholesterol (β = -2.962, 95% CL = -3.532, -2.393 p-value < 0.01), were negatively associated with the triglycerides level.

1.3. Discussion

This paper is to examine the regulatory roles of triglycerides level in three distinct phases of blood pressure. Multiple linear regression models were used to identify the factors that are associated with triglycerides in normal, borderline and hypertensive blood pressure. Finding from the present study found that there are three factors which are significantly across three distinct phases of blood pressure: normal, borderline and hypertensive (see Table 7, Table 8 and Table 9). Total cholesterol, HDL cholesterol and proconvertin were main significant factor across the different blood pressure phases.

Previous study reported by Egger et al. [6] total cholesterol remains statistically significant (p < 0.05) as a risk factor in all models. In another study reported that total cholesterol was increased significantly as the systolic blood pressure increased in both sexes [7]. Besides that, previous study by Lindeberg et al. [8] reported that a negative association was found between triglycerides and HDL cholesterol in Kitava and Sweden. On contrast finding on Swedish subjects, triglycerides and HDL cholesterol were not associated with waist circumference, glucose, BMI, insulin or systolic blood pressure in the Kitavans [8]. Furthermore, triglycerides were negatively associated with HDL cholesterol and positively associated with non-HDL cholesterol [8].

Table 8. Model of associated factor for Triglycerides by Multiple Linear Regression (MLR) for borderline phases of blood pressure.

Variable	Std. Coefficient Beta (β)	95.0% Confidence Interval For B		p-value
		Lower	Upper	
Basic Data				
Height	0.157	-0.834	1.148	0.756
Body Mass Index	1.578	-3.431	6.587	0.536
Weight	-1.261*	-2.417	-0.104	0.033
Lifestyle Factors				
Kilo-calories of physical activity per week	-2.10×10^{-5}	-0.003	0.003	0.987
Smoking status	10.858	-9.051	30.767	0.284
Pack years of smoking	-0.086	-0.326	0.154	0.483
Waist circumference	1.524*	0.190	2.858	0.025
Hip circumference	-0.388	-2.253	1.477	0.683
Clinical factors				
Systolic blood pressure	-0.643	-1.689	0.403	0.228
Diastolic systolic pressure	0.380	-0.338	1.099	0.299
Lipid				
Total cholesterol	0.248**	0.068	0.428	0.007
HDL cholesterol	-2.805**	-3.337	-2.273	0.000
Biochemical				
Glucose	0.561**	0.281	0.841	0.000
Proconvertin	1.123**	0.842	1.403	0.000
Fibrinogen	-0.088	-0.183	0.007	0.068
Diseases				
Family history of heart attack	-5.718	-18.590	7.154	0.383
Diabetes	-18.082	-43.266	7.102	0.159
Incident coronary heart disease	-5.429	-23.009	12.151	0.544
Medication				
Serum Insulin	0.580*	0.095	1.065	0.019
Taking anti-hypertensive	1.304	-11.563	14.171	0.842

medication				
Taking lipid lowering medication	38.301*	7.490	69.113	0.015
R^2		0.887		
Adjust R^2		0.880		
Durbin-Watson		2.051		

*Note: Significant levels: **p < 0.01, *p < 0.05*

Present study also shows that body mass index for hypertensive blood pressure was not significant. According to the Tesfaye et al. [21] risk of hypertension based on Ethiopia (OR = 2.47, 95% CI (1.42, 4.29)) and Vietnam (OR = 2.67, 95% CI (1.75, 4.08)) significantly high on body mass index. Previous study also reported that body mass index is strongly associated with HDL cholesterol and diabetes mellitus among heart disease patients [13]. However, this all report was not support with our finding results about body mass index.

Serum insulin for borderline and hypertensive blood pressure was statistically significant where for normal blood pressure was not significant. Previous studies also show that the insulin was significant to blood pressure and play a major role in the regulation of blood pressure [22]. It also reported by Falkner et al. [4] which insulin also significant in borderline blood pressure and there is a relation between insulin and blood pressure. Another study reported that the insulin levels were higher in hypertensive subject and significant positive correlation was found between insulin level and blood pressure [16].
Present study glucose was significant for borderline blood pressure however does not significant for normal and hypertensive. The previous report also shows that normal blood pressure have less often had fasting blood glucose odd ratio (OR 0.4, 95% Cl: 0.26-0.75) [12]. Henry et al [5] reported in the presence of moderate systolic hypertension can identify subject with glucose level which support our finding result.

Table 9. Model of associated factor for Triglycerides by Multiple Linear Regression (MLR) for Hypertension phases of blood pressure

Variable	Std. Coefficient Beta (β)	95.0% Confidence Interval For B		*p*-value
		Lower	Upper	
Basic Data				
Height	-0.357	-1.218	0.504	0.415
Body Mass Index	1.934	-3.628	7.496	0.495
Weight	-1.122	-2.501	0.257	0.110
Lifestyle Factors				
Kilo-calories of physical activity per week	9.718×10^{-5}	-0.004	0.004	0.959
Smoking status	-2.946	-30.342	24.450	0.833
Pack years of smoking	-0.012	-0.261	0.238	0.927
Waist circumference	0.293	-1.343	1.928	0.725
Hip circumference	0.256	-1.732	2.244	0.800
Clinical factors				
Systolic blood pressure	0.525	-0.014	1.064	0.056
Diastolic systolic pressure	-0.037	-0.779	0.704	0.921
Lipid				
Total cholesterol	0.577**	0.346	0.807	0.000
HDL cholesterol	-2.962**	-3.532	-2.393	0.000
Biochemical				
Glucose	0.146	-0.161	0.452	0.351
Proconvertin	0.842	0.546	1.139	0.000
Fibrinogen	-0.070	-0.187	0.048	0.248
Diseases				
Family history of heart attack	-3.423	-19.359	12.513	0.673
Diabetes	3.636	-22.822	30.093	0.787
Incident coronary heart disease	-4.057	-21.337	13.224	0.645
Medication				
Serum Insulin	0.475**	0.200	0.750	0.001
Taking anti-hypertensive	15.704*	0.111	31.297	0.048

medication				
Taking lipid lowering medication	17.221	-26.836	61.279	0.443
R^2		0.831		
Adjust R^2		0.822		
Durbin-Watson		2.082		

*Note: Significant levels: **p < 0.01, *p < 0.05*

Based on R^2 value on Table 7, 8 and 9, the value of R^2 were 88.8%, 88.7%, 83.1% of the variation in the triglycerides is explained by the independent variables. These three models appear to be very useful and benefit to make prediction since the value R^2 is closer to 1. The Durbin-Watson estimates ranges from zero to four. If Durbin- Watson value $0 < d < 1.5$ near zero shows strong positive autocorrelations and value $2.5 < d < 4$ near four show strong negative autocorrelation. Value between $1.5 < d < 2.5$ shows no autocorrelation. Our present study shows that all of model is range between $1.5 < d < 2.5$ (see table 7, table 8 and table 9). Hence the assumption of the independent all of three models normal, borderline and hypertensive is satisfied. In conclusion, this study demonstrated that triglycerides level is strongly associated with the HDL cholesterol level among normal, borderline and hypertensive systolic blood pressure. Hence, triglycerides level might be a valuable marker to be monitored in normal, borderline and hypertensive systolic blood pressure.

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