Effects of Health Behaviors on Triglyceride/High Density Lipoprotein Cholesterol Ratio

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ABSTRACT— ***Triglyceride (TG)/high density lipoprotein cholesterol (HDL-C) ratio is significantly related to insulin resistance. This study aimed to assess the impact of health behaviors on the TG/HDL-C ratio in Korean adults. This was a cross-sectional study using data from 16,722 subjects (7,328 men and 9,394 women) aged over 20 years of the 7th (2016-2018) Korean National Health and Nutrition Examination Survey (KNHANES). Effects of health behaviors on TG/HDL-C was determined by comparing TG/HDL-C after combining different health behaviors. In male subjects, TG/HDL-C ratio was high if they did not perform aerobic physical activity while smoking or drinking alcohol (p < 0.05). Their TG/HDL-C ratio was also high when smoking and drinking at the same time even if aerobic physical activity was performed (p < 0.05). In female subjects, all TG/HDL-C ratios were high if they did not perform aerobic physical activity except when they were drinking alcohol (p < 0.05). In Koreans, to lower the TG/HDL-C ratio, regular aerobic physical activity is necessary. For males, smoking cessation and abstinence should be done at the same time to lower the TG/HDL-C ratio***

Keywords— Aerobic physical activity, High density lipoprotein cholesterol, Triglyceride

1. INTRODUCTION

Dyslipidemia is a risk factor for cardiovascular disease. Conventionally, roles of triglycerid (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) have been emphasized for a long time. The ability to identify these high-risk individuals before the onset of cardiovascular symptoms has an important clinical advantage. The possibility that the plasma concentration ratio of TG/HDL-C might satisfy this function has been raised [1]. High TG and low HDL-C play an important role in the pathogenesis of insulin resistance and metabolic syndrome [2]. As a result of insulin resistance, an increase in fatty acid production leads to increased TG and very low-density lipoprotein (VLDL) production with a decrease of HDL-C [3].

Both TG and HDL-C are closely related to exercise along with food and alcohol intake. However, it is not well known how health behaviors such as drinking, smoking and exercise affect the TG/HDL-C ratio. In this study, we tried to determine the effects of health behaviors such as drinking, smoking, and physical activity on TG/HDL-C ratio.

2. METHODS

This study was a cross-sectional study using raw data from the 7th (2016-2018) Korean National Health and Nutrition Examination Survey (KNHANES) performed by the Korea Disease Control and Prevention Agency (KDCA). Of a total of 24,269 people, 19,197 people age over 20 years were included. Among them, 16,722 people (7,328 males and 9,394 females) were final subjects, excluding those who did not complete the health survey or check-up. KNHANES data are openly available at https://knhanes.kdca.go.kr [4].

Factors related to demographic characteristics included sex, age, household income level, and education level. Income per household was divided into lower, middle, lower, middle, upper middle, and upper quintiles. Educational level was classified into ≤ 12 years and > 12 years [4]. Health behavior-related factors included data on drinking, smoking, and aerobic physical activity. As for alcohol intake, lifelong non-drinkers and those who drank less than 1 drink per month in the past year were classified as non-drinkers, while those who drank more than 1 drink per month in the last

1 year were classified as drinkers. As for smoking history, those who had never smoked in their lives and those who smoked in the past but not now were classified as non-smokers, while those who were currently smoking were classified as smokers. Aerobic physical activity was considered if subjects were performing 150 minutes or more of moderate-intensity physical activity, 75 minutes or more of high-intensity physical activity, or a mixture of moderate-intensity and high-intensity physical activity (1 minute of high intensity is 2 minutes of moderate intensity). Those who did not do so were classified as non-practicing group. Those who practiced were classified as the practicing group. Anthropometric measurements included body mass index and waist circumference. Blood test results included HDL-C, TG, uric acid, and high sensitivity C-reactive protein (hsCRP) levels. TG/HDL-C ratio was obtained by dividing the TG value by HDL-C.

Data were analyzed using the SPSS statistical program version 25.0 (SPSS Inc., Chicago, IL, USA) using a complex sample analysis. Estimated ratios and average values for demographic characteristics, health behavior-related factors, and metabolic characteristics according to gender were obtained with standard error. To find health behavior factors related to TG/HDL-C ratio, multiple regression analysis was performed with TG/HDL-C ratio as a dependent variable after correcting for demographic and metabolic characteristics. The average value of the TG/HDL-C ratio was compared by gender according to whether each health behavior was performed. By comparing the TG/HDL-C ratio by stratifying the execution of each health behavior into eight categories, we tried to understand the effect of health behavior on the TG/HDL-C ratio. Statistical significance was considered when p value was less than 0.05.

This study was approved by Institutional Review Board of the Kosin University Gospel Hospital (KUGH-2020-10-019) and was based on a nationally representative population-based cross-sectional surveys conducted by KDCA.

3. RESULT

The mean (± SE) age was 46.5 ± 0.3 years for male subjects and 48.7 ± 0.3 years for female subjects. Means of most variables such as BMI, waist circumference, TG, UA, and hsCRP, were significantly higher in male subjects than in female subjects. Demographic and metabolic characteristics of the study population can be seen in table 1.

Table 1. Estimated mean or proportion for characteristics of study subjects.

	Total	Men	Women	p value[1)]
Age (years)	47.6(0.2)	46.5(0.3)	48.7(0.3)	<0.001
Household income (%)				
Low	14.2(0.5)	12.3(0.6)	16.1(0.6)	<0.001
Middle-low	17.8(0.5)	16.9(0.6)	18.6(0.6)	
Middle	21.4(0.5)	21.6(0.7)	21.1(0.6)	
Middle-high	22.9(0.6)	23.9(0.7)	21.9(0.6)	
High	23.7(0.8)	25.2(0.9)	22.3(0.8)	
Education (years, %)				
≤12	58.1(0.8)	54.0(1.0)	62.0(0.8)	<0.001
>12	41.9(0.8)	46.0(1.0)	38.0(0.8)	
Current drinking (%)				
No	41.3(0.5)	27.4(0.6)	55.1(0.6)	<0.001
Yes	58.7(0.5)	72.6(0.6)	44.9(0.6)	
Current smoking (%)				
No	78.4(0.5)	62.5(0.8)	94.1(0.3)	<0.001
Yes	21.6(0.5)	37.5(0.8)	5.9(0.3)	
Aerobic exercise (%)				
No	54.0(0.6)	50.7(0.8)	57.2(0.7)	<0.001
Yes	46.0(0.6)	59.3(0.8)	42.8(0.7)	
Body mass index (kg/m^2)	24.0(0.04)	24.6(0.1)	23.4(0.1)	<0.001
Waist circumference (cm)	82.4(0.1)	86.2(0.1)	78.5(0.2)	<0.001
Fasting glucose (mg/dL)	100.3(0.2)	102.8(0.4)	97.7(0.3)	<0.001
HDL-C (mg/dL)	51.0(0.1)	47.3(0.2)	54.8(0.2)	<0.001
LDL-C (mg/dL)	114.1(0.3)	111.9(0.5)	116.3(0.4)	<0.001
TG (mg/dL)	139.5(1.3)	164.5(2.2)	114.2(1.1)	<0.001
Uric acid (mg/dL)	5.18(0.01)	5.93(0.02)	4.42(0.01)	<0.001
hsCRP (mg/dL)	1.17(0.02)	1.24(0.03)	1.10(0.02)	<0.001
TG/HDL-C	3.18(0.04)	3.98(0.07)	2.37(0.03)	<0.001

Data are shown as mean or percentage (SE: standard error). [1)] Comparison between men and women. HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol; TG: triglyceride; hsCRP: high sensitivity C reactive protein.

Table 2 shows results of comparing the TG/HDL-C ratio according to health behavior by sex. For male subjects, the average TG/HDL-C ratio of drinkers was 4.15 (95% CI: 3.97 - 4.33), which was significantly higher than that of non-drinkers at 3.51 (95% CI: 3.36 - 3.65) ($p < 0.001$). Average TG/HDL-C ratios of smokers and those who did not practice aerobic physical activity were 4.75 (95% CI: 4.51 - 5.01) and 4.27 (95% CI: 4.04 - 4.51), respectively, which were statistically significantly ($p < 0.001$) higher than those of non-smokers and those who did aerobic physical activity [3.50 (95% CI: 3.35 - 3.65) and 3.67 (95% CI: 3.51 - 3.83), respectively]. In female subjects, the average TG/HDL-C ratio of drinkers was 2.09 (95% CI: 2.01 - 2.18), which was significantly ($p < 0.001$) lower than that of non-drinkers at 2.59 (95% CI: 2.51 - 2.67). Average TG/HDL-C ratios of smokers and those who did not practice aerobic physical activity were 2.84 (95% CI: 2.50 - 3.18) and 2.52 (95% CI: 2.43 - 2.61), respectively, which were statistically significantly ($p < 0.001$) higher than those of non-smokers and those who did aerobic physical activity [2.34 (95% CI: 2.27 - 2.40) and 2.16 (95% CI: 2.08 - 2.24), respectively].

Table 2. Comparison of TG/HDL-C ratios stratified by health behaviors

Health Behaviors		Male	t	p value	Female	t	p value
Current drinking	No	3.51(3.36, 3.65)	5.61	< 0.001	2.59(2.51, 2.67)	-8.89	< 0.001
	Yes	4.15(3.97, 4.33)			2.09(2.01, 2.18)		
Current smoking	No	3.50(3.35, 3.65)	8.66	< 0.001	2.34(2.27, 2.40)	2.90	0.004
	Yes	4.75(4.51,5.01)			2.84(2.50, 3.18)		
Aerobic exercise	No	4.27(4.04, 4.51)	-4.15	< 0.001	2.52(2.43, 2.61)	-6.03	< 0.001
	Yes	3.67(3.51, 3.83)			2.16(2.08, 2.24)		

Data are shown as mean (95% CI)

As for health behavioral factors related to the TG/HDL-C ratio, it was found that the TG/HDL-C ratio was higher among smokers and those who did not engage in aerobic physical activity in male subjects. The TG/HDL-C ratio was also significantly higher in female non-drinkers and smokers ($p < 0.01$, Table 3).

Table 3. Multiple linear regression analysis for TG/HDL-C ratio

Sex	Variables	β	S.E.	95%(CI)	t	p value
Male	Current smoking (No vs. Yes)	1.094	0.120	(0.858, 1.330)	9.085	< 0.001
	Aerobic exercise (No vs. Yes)	-0.408	0.120	(-0.644, -0.172)	-3.392	< 0.001
Female	Current drinking (No vs. Yes)	-0.263	0.057	(-0.375, -0.152)	-4.627	< 0.001
	Current smoking (No vs. Yes)	0.533	0.172	(0.197, 0.870)	3.109	0.002

Table 4 shows results of comparing average values of each TG/HDL-C ratio by combining health behaviors. Non-smokers, non-drinkers, and those who performed aerobic physical activity were used as the reference group. For male subjects, the average TG/HDL-C ratio of the reference group was 3.09 (95% CI: 2.85 - 3.33). Mean TG/HDL-C ratio of the group of non-smokers, drinkers, and not performing aerobic physical activity was 3.96 (95% CI: 3.57 – 4.34), which was significantly higher than the reference group ($p < 0.01$). However, there was no significant difference between the reference group and the group of non-smokers, drinkers, and performing aerobic physical activity. In the case of smokers, their TG/HDL-C ratios were significantly higher than that of the reference group regardless of whether or not aerobic physical activity was performed when drinking alcohol ($p < 0.001$). In non-drinkers did not perform aerobic physical activity, the TG/HDL-C ratio was 4.56 (95% CI: 4.03 – 5.10), which was significantly higher than the reference group ($p < 0.001$). Thus, for male subjects, their TG/HDL-C ratios were high if they were smokers or drinkers without performing aerobic physical activity. And, for both smokers and drinkers, the TG/HDL-C ratio was high even with aerobic physical activity. For female subjects, the average TG/HDL-C ratio of the reference group was 2.38 (95% CI: 2.28 – 2.49). In the case of non-smokers, the TG/HDL-C ratio was significantly lower in drinkers with or without aerobic physical activity compared to that of the reference group ($p < 0.01$). On the other hand, in non-drinkers who did not perform aerobic physical activity, the TG/HDL-C ratio was 2.69 (95% CI: 2.57, 2.81), which was significantly higher than that of the reference group ($p < 0.01$). In the case of the smokers who neither drinking nor performing aerobic physical activity, the TG/HDL-C ratio was statistically significantly higher than that of the reference group ($p < 0.05$). For all other cases, the TG/HDL-C ratios were not significantly different from that of the reference group. That is, the TG/HDL-C ratio was high in female subjects when they did not engage in aerobic physical activity except when they were drinking alcohol.

Table 4. Comparison of TH/HDL-C ratios stratified by health behaviors

Sex	Current Smoking	Current Drinking	Aerobic Exercise	TG/HDL-C, Means (95% CI)	p Value
Male	(-)	(-)	(+)	3.09(2.85, 3.33)	-
	(-)	(-)	(-)	3.35(3.16, 3.55)	0.837
	(-)	(+)	(-)	3.96(3.57, 4.34)	0.001
	(-)	(+)	(+)	3.35(3.14, 3.57)	0.785
	(+)	(-)	(+)	3.57(3.22, 3.92)	0.148
	(+)	(-)	(-)	4.56(4.03, 5.10)	<0.001
	(+)	(+)	(+)	4.58(4.20, 4.97)	<0.001
	(+)	(+)	(-)	5.21(4.71, 5.71)	<0.001
Female	(-)	(-)	(+)	2.38(2.28, 2.49)	-
	(-)	(-)	(-)	2.69(2.57, 2.81)	0.001
	(-)	(+)	(-)	2.14(2.04, 2.25)	0.009
	(-)	(+)	(+)	1.89(1.76, 2.02)	<0.001
	(+)	(-)	(+)	2.88(1.72, 4.03)	1.000
	(+)	(-)	(-)	3.35(2.75, 3.95)	0.015
	(+)	(+)	(+)	2.26(1.94, 2.57)	1.000
	(+)	(+)	(-)	3.11(2.34, 3.88)	0.480

4. DISCUSSION

In this study, we tried to determine effects of health behaviors such as drinking, smoking, and physical activity on the TG/HDL-C ratio. Both TG and HDL-C are correlated with lifestyle habits such as diet, drinking, and exercise. TG and HDL-C have an inverse correlation with each other [5]. A high TG/HDL-C ratio indicates an increased cardiometabolic risk, requiring additional risk assessment and clinical intervention. Therefore, the TG/HDL-C ratio needs to be considered as a simple diagnostic tool that can quickly recognize the risk [6]. However, it is not yet clear how TG/HDL-C ratio changes according to health behaviors. As a result of this study about the relationship between health behavior and TG/HDL-C ratio, the TG/HDL-C ratio was higher in men when they were not performing aerobic physical activity. In the case of smoking and drinking, the TG/HDL-C ratio was higher even after performing aerobic physical activity. The TG/HDL-C ratio was also high in women when they did not engage in aerobic physical activity except for female drinkers.

Chronic smokers are insulin resistant. They are more likely to develop hyperinsulinemia and dyslipidemia than nonsmokers [7]. Another study has found that serum cholesterol, TG, VLDL-C, and LDL-C concentrations are significantly higher whereas HDL-C concentrations are significantly lower in smokers, than in non-smokers [8]. Several mechanisms have been proposed for these results, including an increase in free fatty acids. As a result of insulin resistance, when free fatty acids are increased, production of TG and VLDL are also increased with increased activity of cholesteryl ester transporter, resulting in abundant TG in HDL but deficient cholesteryl ester. In fact, in this study, TG/HDL-C ratios in both men and women were significantly higher in smokers than in non-smokers. However, in the case of drinking, the TG/HDL-C ratio of drinkers was higher than that of non-drinkers in men, lower than that of non-drinkers in women. This was partially consistent with previous results showing that moderate drinking was inversely associated with TG levels in those aged 70 years or more, and that HDL-C levels were positively related in all age groups [9]. However, this study had a limitation in that the level of drinking was evaluated only by whether or not drinking was present. There was no quantitative evaluation of the amount of alcohol consumed. A study on Japanese also showed that the TG/HDL-C ratio was high in smokers. It has suggested that high-intensity physical activity is necessary to lower the TG/HDL-C ratio [10]. In the present study, it was confirmed that the TG/HDL-C ratio increased when subjects were not performing aerobic physical activity in men and women.

This study has several limitations. First, since this is a cross-sectional study, a causal relationship in the association of TG/HDL-C ratio with health behavior could not be confirmed. In other words, it was not possible to determine whether a high TG/HDL-C ratio affected health behavior, or whether the TG/HDL-C ratio was increased by the influence of healthy behavior. Therefore, longitudinal studies are needed to confirm this. Second, data used in this study were obtained from the KNHANES. Although fasting was maintained before blood tests, dietary conditions such as eating habits and fasting duration that could affect TG levels were not considered. Finally, data from the KNHANES used in this study might be biased because household income, education level, and health behavior characteristics were based on individual memories or subjective judgments.

5. REFERENCES

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