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Magnitude of the Difference between Fasting and Non-fasting Triglycerides, and Its Dependent Factors

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Abstract

Background: It is largely unknown about the magnitude of the difference between fasting and non-fasting triglycerides, and whether this difference is dependent on certain potential cardiovascular disease (CVD) risk factors.

Methods: We conducted a cross-sectional study of 8,073 participants from the National Health and Nutrition Examination Survey, 2005-2010. Fasting status was classified into two groups: fasting (≥8 hours) and non-fasting status (<8 hours). The difference between fasting and non-fasting triglycerides its dependent CVD risk factors were estimated with linear regression model.

Results: Overall, fasting participants had lower triglycerides than non-fasting participants after adjusting for covariates (difference=4.22 mg/dL; P=0.049). Triglycerides levels at fasting status was interacted with hypertension (P=0.05), antihyperlipidemic agent use (P=0.07) and LDL cholesterol (P=0.04). In the separate analyses of the participants with and without hypertension, antihyperlipidemic agent use, or with high and low levels of LDL cholesterol, fasting triglycerides were much lower than non-fasting triglycerides only in participants with hypertension (difference=14.24 mg/dL; P=0.03), antihyperlipidemic agent use (difference=14.10 mg/dL; P=0.02), or LDL cholesterol <130 mg/dL (difference=6.46 mg/dL; P=0.02).

Conclusions: The difference between fasting and non-fasting triglycerides was 4 mg/dL in the overall samples, and factors that determine the magnitude of differences were hypertension status, antihyperlipidemic agent use and LDL cholesterol levels. These findings may help us to use fasting and non-fasting triglycerides properly to assess the risk of CVDs.

Keywords: Lifestyle; Intervention; Behavioral; Anthropometry; Biochemical

Abbreviations:

BMI: Body Mass Index; CRP: C-Reactive protein; CVD: Cardiovascular disease; NHANES: National Health and Nutrition Examination Survey

Introduction

High level of triglyceride is a well-recognized risk factor for cardiovascular diseases (CVDs) [1-3]. Current clinical guideline suggests that triglycerides should be measured in fasting blood samples in order to assess the risk of CVDs accurately [1,4], mainly because the levels of non-fasting triglycerides are generally higher than that of fasting triglycerides due to postprandial influence [5,6]. However, as individuals are in non-fasting state most of the time, non-fasting triglycerides have been proven to be more useful than fasting triglycerides to predict future CVDs [2,7,8]. This has raised an important issue that fasting triglycerides may underestimate the true risk of CVDs. Since fasting triglycerides were not considered to be an independent risk factor for CVDs in some epidemiologic studies [5,7], further studies on the fasting and non-fasting triglycerides are warranted to improve the role of triglycerides in assessing CVD risk.

Although levels of non-fasting triglycerides are generally higher than that of fasting triglycerides [5], it is not well known about the magnitude of the difference between fasting and non-fasting triglycerides, and whether this difference is dependent on certain potential CVD risk factors. Understanding these two questions will help us to use both fasting and non-fasting triglycerides properly to assess the risk of CVDs. For instance, if the difference between fasting and non-fasting triglycerides is dramatic, and non-fasting triglycerides are much higher than fasting triglycerides in certain participants, non-fasting triglycerides may be more predictive than fasting triglycerides for assessing the risk of CVDs. In other words, using fasting triglycerides may significantly underestimate the risk of CVDs as compared to using non-fasting triglycerides. Conversely, if a very small or no difference between fasting and non-fasting triglycerides is observed in some people, fasting and non-fasting triglycerides can be used interchangeably to predict CVD risk. Further, existing publications suggest that the magnitude of the difference between fasting and non-fasting triglycerides is dependent not only on dietary fat intake, but also on the participants' age, gender and some lipid metabolic factors that may play a role in fat metabolism [9-11]. However, few studies have dissected the potential influence of a profile

of multiple potential CVD risk factors (e.g. demographic and lifestyle factors, hypertension, diabetes, antihyperlipidemic agent use and CVD biomarkers) on the difference between fasting and non-fasting triglycerides. Therefore, the aims of our study were to examine the magnitude of the difference between fasting and non-fasting triglycerides, and to determine whether this difference is dependent on certain potential CVD risk factors.

Materials and Methods

Study setting and subjects

The present study was a part of the National Health and Nutrition Examination Survey (NHANES), which is a continuous program examining the health and nutrition of a nationally representative population in the U.S. every year. We initially included all the relevant data from the NHANES between 2005 and 2010 for our study (n=32,971). After excluding the participants with missing fasting hours (n=5,679) and triglyceride measurements (n=19,219), we eventually included 8,073 participants for our analysis. The age was not significantly different between included and excluded participants (30 vs. 31 years; P=0.071). The BMI in included participants was slightly lower than in excluded participants (25.3 vs. 25.6 kg/m^2; P=0.015). Our investigation was exempted from ethical review by the University of Cincinnati Institutional Review Board as the NHANES has written consent from all participants.

Demographic, lifestyle and other data collection

Age, gender, race, physical activity, alcohol intake, total fat intake, use of antihyperlipidemic agents, history of coronary heart disease and smoking status were collected by experienced interviewers via structured questionnaire. Body mass index (BMI) was measured at interview. Smoking status was classified as current, past and never smokers. Race was classified into five groups: Mexican American, Hispanic, non-Hispanic White, non-Hispanic Blacks and others. The levels of physical activity were classified into three categories: vigorous, moderate and sedentary lifestyle. Vigorous lifestyle was defined as large increases in breathing or heart rate and was done for at least 10 minutes continuously every week. Moderate lifestyle was defined if participants had small increases in breathing or heart rate such as brisk walking or carrying light loads for at least 10 minutes continuously every week.

The rest participants were classified into sedentary lifestyle group. Total fat intake was estimated from 24-hour food recall (from midnight to midnight) before blood draw. Use of antihyperlipidemic agents (i.e. HMG-CoA reductase inhibitors, fibric acid derivatives, bile acid sequestrants and cholesterol absorption inhibitors) was ascertained during a one-month period prior to the date of interview. The dose of antihyperlipidemic agent use was not available, thus only binary data of antihyperlipidemic agent use (yes/no) were analyzed. Total length of "food fast" at the time of blood draw was ascertained by questionnaire. Fasting subjects were defined if participants had fasted (except water) for at least 8 hours at the time of blood draw. The rest was defined as non-fasting subjects. We used 8 hours as a cut point to define fasting and non-fasting status because it is a clinical routine procedure to measure triglycerides in ≥ 8 hours fasting blood samples [1,4] and 8-hour point gave bigger difference between fasting and non-fasting triglycerides than other cut-points (e.g., 6, 10 or 12 hours) in our study.

Hypertension and diabetes ascertainment

According to the National Institute of Health (*http://www.nhlbi.nih.gov/health/health-topics/topics/hbp/*), hypertension was defined if an average of blood pressure readings (up to 4 times per participant) was greater than 140/90 mmHg. Hemoglobin A1C (glycohemoglobin) was measured by the Diabetes Diagnostic Laboratory at the University of Missouri-Columbia using Primus CLC330 and 385. As suggested by the American Diabetes Association (*http://www.diabetes.org/diabetes-basics/diagnosis/*), diabetes was diagnosed at an A1C of greater than or equal to 6.5%.

Measurement of CVD biomarkers

All blood samples were properly processed, stored and shipped before analysis. Total cholesterol and triglycerides were measured enzymatically in serum by using the Roche Hitachi 717 and 912. Adjustment for the change of measurement instrument is not necessary, as the difference of cholesterol or triglyceride measurements was very small between instruments. HDL cholesterol was measured in serum with HDL-cholersterol direct immunoassay method. LDL cholesterol was calculated by using the following equation: [LDL cholesterol]=[total cholesterol]-[HDL cholesterol]-[triglycerides/5]. C-reactive protein (CRP) was quantified by latex-enhanced nephelometry. CRP levels below the lowest detection limit (0.02 mg/dL) were coded as missing value.

Statistical analysis

We compared the data on demographic and lifestyle factors, hypertension, diabetes, antihyperlipidemic agent use and CVD biomarkers between fasting and non-fasting participants. The relationship of demographic and lifestyle factors, hypertension, diabetes, antihyperlipidemic agent use and CVD biomarkers with triglycerides was performed. P for trend was estimated with linear regression model.

The association between triglycerides (continuous) and fasting status (<8 and ≥ 8 hours) was analyzed with linear regression model, in which triglycerides and fasting status were dependent and independent variable, respectively. Covariates in the model included age (continuous), gender, BMI (<20, 20-24, 25-29, 30-34, 35+ kg/m^2), hypertension (yes/no), diabetes (yes/no), total fat intake (in quartiles), history of coronary heart disease (yes/no), use of antihyperlipidemic agents (yes/no), physical activity (vigorous, moderate and sedentary lifestyle), race (Mexican American, Hispanic, Non-Hispanic White, Non-Hispanic Black, other race), smoking status (current smoker, past smoker and never smoked), HDL cholesterol, LDL cholesterol, alcohol intake (0, 1, 2, 3, 4+ drinks/day), CRP (in quartiles). Because the NHANES is composed of multiple sampling surveys, we also adjusted survey weights in the linear regression models. After adjusting for the covariates as mentioned above, the mean and 95% confidence interval (CI) in fasting and non-fasting participants, the difference between these two groups and P for this difference were performed with the linear regression model.

To assess whether certain potential CVD risk factors have an influence on the difference between fasting and non-fasting triglycerides, the interaction between all potential CVD risk factors and fasting status in relation to triglycerides was also tested with the linear regression models. In the models, the wald P value from interaction term (potential CVD risk factors* fasting status) in relation to triglycerides was estimated. Because the power of interaction test is

low [12], P<0.10 was considered to be statistically significant. Once we found a significant interaction, we performed subgroup analysis after stratifying by the potential CVD risk factors that had interaction with fasting status in relation to triglycerides. To avoid the potential bias by using only one cut-point of a continuous variable while creating subgroups, we used median and 75th percentile of such a variable to create subgroups for subgroup analysis. All analyses were performed by the SAS (Version 9.3, SAS Institute Inc., Cary, NC).Discussion

The study was a community-based intervention study to assess the effect of a short term, school based lifestyle intervention program on the health behavior and anthropometric measurements of school going adolescents and determine the factors influencing adoption of healthy lifestyle practices among the school going adolescents. A total of 384 students were enrolled in the study (191 in intervention group and 193 in control group. The age of the participating children varied from 13-15 years in both the groups. 371 participants were evaluated after the intervention. This reduction was due to the daily variation in the attendance of the school children. However, the follow up rate of 96.6% was achieved.

Awareness was created among the children after the intervention that physical activity can be routinely implemented in daily life. There was a statistically significant increase in the behavior of children to play outside when they had free time ($p<0.05$). The children were encouraged by the parents at home as they had been explained the beneficial effects of physical games and harmful effects of playing computer games. There was 20% increase from the baseline in the children who did some kind of physical activity, of which 15% did it regularly. The children had also been taught simple physical exercises. The children had also been taught simple physical exercises during the sessions which could be easily done at home.

A similar increase in physical activity was observed in CATCH study [13-15], where the time spent in moderate physical activity in physical education classes increased from 40% to 50% after the intervention. In the intervention group, 20% of the children started watching television for less than 2 hours after intervention. Another school health program-Planet Health also produced similar reduction in television watching and this was possible due to efforts of the parents [6]. This shows that parents are also vital stakeholders in a school based intervention program. But behavior change should be facilitated in children regarding TV watching rather than through enforcement by parents. Substitution of this leisure time with outdoor games should be promoted and caution should be taken that parents might very well exploit their children to academic activities and shun their leisure activity.

After the intervention, there has been significant rise in the proportion of children who never skipped breakfast from 56% to 68.5%. During the session on diet, it was found that most children were skipping breakfast to reduce weight and having an excuse of getting late to school. But the importance of taking breakfast was clearly explained during the sessions. The proportion of children who opted for fruits in case food was not prepared at home also increased from 57.4% at baseline to 67.9% and fruit intake among children. About 16.3% of the students in the intervention group had also restricted their frequency of intake of fast foods to once a month and this change in the behavior being very significant. This change could be attributed to the intervention in the schools' canteen, support from the parents and the awareness generated among the children regarding harmful effects of junk food. Other studies have also resulted in increased fruit intake in children like Be Smart [16], CATCH [15], and APPLES [17].

In the intervention group, 22% of the children no more found it difficult to handle things that resulted from their body in adolescent changes and this change was statistically significant. This was one area which had not been studied in any other study. The intervention also resulted in a significant change in the attitude of the students towards HIV/AIDS. At baseline, 30.4% of students reported that they would stop talking to their friend with HIV/AIDS and post-intervention only 4.4% reported the same and this change was statistically significant. This could be attributed to external factors like the mass media where a lot of advertisements of National AIDS Control Program reflect the same things. The intervention produced a significant change in the self-reported attitude of children towards their body. At baseline, only 13.1% of children thought that when anything wrong happened to them, it was not because of them which increased to 32.1% after the intervention, being a significant change. This area needs a lot of intervention and the children need more counseling on personality.

There was improvement in the score of the children on knowledge regarding risk factors of chronic NCDs in the intervention group while compared to the control group, where knowledge level either remained the same or decreased. After the intervention, children atleast had known as to how NCDs were otherwise known as and the common NCDs and the associated risk factors. This awareness on lifestyle diseases among school children is very essential as it would help them figure out NCDs from fever and infections and they would be able to incorporate healthy lifestyle practices into their daily lives [18]. There was a significant increase in the proportion of children knowing the correct formula of calculating BMI. It was 25.1% at baseline and increased to 75.5% after the intervention. It was primarily because of the lifestyle diary where the children were asked to calculate their own BMI and plot on charts.

Blood sampling was done in 50% of the intervention group and 25% of the control group. As a pleasant surprise, almost all the parents consented to blood sampling in their children, in contrary to the popular myth that consent rates would be low due to apprehensions among the parents. A proper explanation and advantages of biochemical testing always helps to meet the objective. But there was no significant change in the biochemical parameters like lipid profile and blood sugar in the children after the intervention. The Kids N Fitness Program was a family centered lifestyle intervention which evaluated the effect of the program on 8-16 year old children and it produced significant changes in some parameters like total cholesterol, LDL and triglycerides, thus showing that even family-centered programs which are very intensively structured have lesser impact on such parameters [19].

There was no significant change in the anthropometric indicators like weight, BMI and waist hip ratio after the intervention. It is the short time period of intervention that could be attributed to the insignificant change achieved in all these parameters. Various studies have shown that most of the studies with shorter intervention periods have been ineffective in reducing the mean BMI of the children [20]. It clearly outlines the role of other factors in producing change in such parameters. The present study concludes that 12-week lifestyle intervention is feasible in school settings and helped in changing health behavior of the students. Longer duration of intervention may be required for change in anthropometry and biochemical profile.

Results

Demographic and lifestyle factors, hypertension, diabetes, antihyperlipidemic agent use and CVD biomarkers stratified by fasting status

Among 8,073 participants, 41% (n=3,296) of them had been fasted for at least 8 hours before blood withdrawn. Fasting participants were significantly older and more likely to be current or past smokers, had higher BMI and total fat intake than non-fasting participants (Table 1). All the other variables were not significantly different between fasting and non-fasting participants (Table 1).

Variables	Fasting status		P value
	Non-fasting participants	Fasting participants	
N	4777	3296	---
Age (years)*	18 (8, 44)	28 (15, 51)	< 0.01
Gender (% of male)	47.9	49	0.34
Body mass index (kg/m^2)	24.5 (7.4)	26.4 (7.7)	< 0.01
Total fat intake (mg/day)*	68.0 (46.8, 97.2)	71.8 (48.6, 101.0)	< 0.01
Alcohol intake 4+ drinks/day (%)	6.6	8.1	< 0.01
Hypertension (%)	10.1	11	0.38
Diabetes (%)	6.1	6.5	0.61
History of coronary heart disease (%)	3.5	4.6	0.19
Antihyperlipidemic agent use (%)	8.3	8.1	0.76
Physical activity			0.14
Vigorous (%)	32	31.5	
Moderate (%)	18.3	20.1	
Sedentary (%)	49.7	48.5	
Race			0.28
Mexican American (%)	26.3	27.4	
Hispanic (%)	3.3	3	
Non-Hispanic White (%)	39.7	37.8	
Non-Hispanic Black (%)	25.9	27.3	
Others (%)	4.9	4.6	
Smokers			< 0.01
Current (%)	10.1	13.3	
Past (%)	10.2	14	
Cardiovascular Biomarkers			
HDL cholesterol (mg/dL)	54.2 (15.5)	54.1 (15.6)	0.82
LDL cholesterol (mg/dL)	110 (35)	109 (35)	0.45
C-reactive protein (mg/dL)*	0.16 (0.06, 0.42)	0.16 (0.06, 0.45)	0.7

Values with normal distribution are shown in means (standard deviation), unless otherwise specified. *Values with skew distribution are shown in medians (inter-quartile range).

Table 1: Participants' demographic and lifestyle factors, hypertension, diabetes, antihyperlipidemic agent use and cardiovascular biomarkers stratified by fasting status (N=8,073).

Association of participants' demographic and lifestyle factors, hypertension, diabetes, antihyperlipidemic agent use and CVD biomarkers with triglycerides

Higher levels of triglycerides were associated with increased proportion of fasting participants, current smokers and greater levels of LDL cholesterol (Table 2). All the other variables were not associated with triglycerides (Table 2).

Variables	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P value
N	1592	1608	1601	1643	1629	---
Age (years)*	22	22	23	20	21	0.28
Gender (% of male)	48.9	50.1	49.5	45.9	47.7	0.14
Body mass index (kg/m2)	25.1	25.3	25.4	25.6	25.3	0.37
Total fat intake (mg/day)*	68.6	68.7	70.9	69.8	69.3	0.3
Alcohol intake 4+ drinks/day (%)	7.5	8.5	6.9	6.6	6.6	0.41
Fasting status ≥ 8 hours (%)	43	42.9	41	36.8	40.6	0.03
Hypertension (%)	11.1	9.7	10.3	9.7	11.5	0.63
Diabetes (%)	6.9	6.2	5.9	6.2	6.3	0.48
History of coronary heart disease (%)	4.2	4.1	3.8	3.9	3.9	0.8
Antihyperlipidemic agent use (%)	8.2	9.2	7	8.7	8	0.71
Physical activity						
Vigorous (%)	30.2	32.7	32.5	30.9	32.7	0.43
Moderate (%)	20.3	19.5	17.6	18.4	19.4	0.88
Sedentary (%)	49.6	47.8	50	50.8	47.9	0.63
Race						
Mexican American (%)	26.6	26.5	25.9	26.8	27.8	0.33
Hispanic (%)	3.2	3.1	3.9	2.7	3.1	0.76
Non-Hispanic White (%)	38.3	39.7	39.4	39.4	37.6	0.46
Non-Hispanic Black (%)	27.2	25.4	26.5	26.7	26.3	0.76
Others (%)	4.7	5.4	4.4	4.3	5.2	0.59
Smokers						
Current (%)	10.4	11.5	11.9	11.7	11.4	0.04
Past (%)	11.9	10.8	12.6	11.6	11.8	0.05
Biomarkers						
HDL cholesterol (mg/dL)	54.4	54.8	53.5	53.5	54.5	0.79
LDL cholesterol (mg/dL)	91	104	112	119	120	< 0.01

C-reactive protein (mg/dL)*	0.17	0.16	0.15	0.16	0.38	0.32
Values with normal distribution are shown in means, unless otherwise specified. *Values with skew distribution are shown in medians.						

Table 2: Participants' demographic and lifestyle factors, hypertension, diabetes, antihyperlipidemic agent use and cardiovascular biomarkers stratified by quintiles of triglycerides (N=8,073).

Association between triglycerides and fasting status, and its dependent factors

Overall, fasting participants had lower triglycerides than non-fasting participants in the unadjusted model, and the magnitude of the difference was 3.65 mg/dL (Table 3). In the multivariate model, the magnitude of the difference between fasting and non-fasting triglycerides did not change appreciably, and remained statistically significant (Table 3).

Models	Triglyceride levels, mg/dL (95% confidence interval)			P value
	Non-fasting participants	Fasting participants	Difference	
	N=4777	N=3296		
Unadjusted	119 (117, 121)	115 (113, 117)	3.65 (0.71, 6.59)	0.01
Adjusted*	131 (120, 143)	127 (116, 138)	4.22 (0.03, 8.41)	0.049
*Values were adjusted for age (continuous), gender, body mass index (<20, 20-24, 25-29, 30-34, 35+ kg/m^2), hypertension (yes/no), diabetes (yes/no), total fat intake (in quartiles), history of coronary heart disease (yes/no), use of antihyperlipidemic agents (yes/no), physical activity (vigorous, moderate and sedentary lifestyle), race (Mexican American, Hispanic, Non-Hispanic White, Non-Hispanic Black, other race), smoking status (Current smoker, past smoker and never smoked), HDL cholesterol, LDL cholesterol, alcohol intake (0, 1, 2, 3, 4+ drinks/day), C-reactive protein (in quartiles) and survey weights.				

Table 3: Association between triglycerides and fasting status in overall samples: multivariable analysis.

Fasting status was interacted with hypertension (P=0.05), antihyperlipidemic agent use (P=0.07) and LDL cholesterol (P=0.04), but not with other potential CVD risk factors in relation to triglycerides (all P ≥ 0.10). In the separate analyses of the participants with and without hypertension, antihyperlipidemic agent use, or with high and low LDL cholesterol levels (Table 4), fasting triglycerides were much lower than non-fasting triglycerides only in participants with hypertension (difference=14.24 mg/dL; P=0.03), antihyperlipidemic agent use (difference=14.10 mg/dL; P=0.02), or LDL cholesterol <130 mg/dL (difference=6.46 mg/dL; P=0.02). When different cut-point (106 mg/dL) was used to create subgroups for high and low LDL cholesterol levels, we found that non-fasting triglycerides were still higher than fasting triglycerides in participants with LDL cholesterol <106 mg/dL (Table 4).

Variables	Groups	N	Triglyceride levels, mg/dL (95% confidence interval)*			P value‡
			Non-fasting participants	Fasting participants	Difference	
Hypertension	Yes	843	131 (96, 167)	117 (81, 153)	14.24 (1.42, 27.06)	0.03
	No	5260	123 (109, 138)	121 (107, 135)	2.35 (-2.96, 7.66)	0.39
Antihyperlipidemic agent use	Yes	663	144 (121, 167)	130 (107, 153)	14.10 (2.65, 25.55)	0.02
	No	7410	125 (111, 139)	123 (109, 137)	2.41 (-2.14, 6.96)	0.3
LDL cholesterol (mg/dL)	< 106*	3983	114 (97, 131)	107 (91, 124)	6.46 (0.56, 12.36)	0.03
	106+*	4090	143 (127, 159)	142 (126, 158)	1.41 (-4.57, 7.39)	0.64
	<130†	5919	124 (110, 138)	118 (104, 132)	5.89 (1.05, 10.73)	0.02
	130+†	2154	146 (125, 167)	148 (127, 169)	-1.49 (-10.04, 7.06)	0.73
*Values are divided by using median as cut point. †Values are divided by using 75th percentile of the variable as cut point. ‡Values were adjusted for age (continuous), gender, body mass index (<20, 20-24, 25-29, 30-34, 35+ kg/m^2), hypertension (yes/no), diabetes (yes/no), total fat intake (in quartiles), history of coronary heart disease (yes/no), use of antihyperlipidemic agents (yes/no), physical activity (vigorous, moderate and sedentary lifestyle), race (Mexican American, Hispanic, Non-						

Hispanic White, Non-Hispanic Black, other race), smoking status (Current smoker, past smoker and never smoked), HDL cholesterol, LDL cholesterol, alcohol intake (0, 1, 2, 3, 4+ drinks/day), C-reactive protein (in quartiles) and survey weights.

Table 4: Association between triglycerides and fasting status stratified by hypertension, antihyperlipidemic agent use and LDL cholesterol.

Discussion

In this cross-sectional study of U.S. general population, we have demonstrated that levels of fasting triglycerides were 4 mg/dL lower than that of non-fasting triglycerides in the overall samples. More importantly, the difference between fasting and non-fasting triglycerides was dependent on the participants' hypertension status, antihyperlipidemic agent use and LDL cholesterol levels. These findings will help us to better understand the role of triglycerides for assessing CVD risk.

The primary mechanism for the difference between fasting and non-fasting triglycerides is suggested to be related to the amount of fat intake within 8 hours before blood draw [13]. However, this mechanism was not supported by our study, in which the magnitude of the difference between fasting and non-fasting triglycerides was not significantly influenced by the total fat intake. This could be explained by two reasons: First, as stated at Method section, the total fat intake in our study was estimated from the 24-hour food recall from midnight to midnight before blood draw; it was unclear what participants actually ate before blood draw. Thus, the untargeted fat intake data could be one of the possible causes for this finding. Second, other factors such as disorder of lipid metabolism may be more important than the amount of fat intake in determining the difference between fasting and non-fasting triglycerides. It has been suggested that impaired glucose or fat tolerance plays an important role on the levels of non-fasting triglycerides [11,14].

Consistent with many human studies [7,15,16], fasting triglycerides were much lower than non-fasting triglycerides. Although the overall difference between fasting and non-fasting triglycerides was approximately 4 mg/dL, this difference is not the same in all participants. In the current study, we found that non-fasting triglycerides were much higher than fasting triglycerides in participants with hypertension, antihyperlipidemic agent use or lower level of LDL cholesterol. The primary reason for significant and large difference between fasting and non-fasting triglycerides in participants with hypertension and antihyperlipidemic agent use is that both hypertension and antihyperlipidemic agent use are associated with factors that can elevate triglycerides or lipid disorder. Hypertension is found to be positively related to insulin resistance which causes glucose disorder [17] and increased triglyceride levels [18]. Similarly, in participants with antihyperlipidemic agent use, due to the efficacy of this type of medications, more or less these participants were suffering from lipid disorder during the antihyperlipidemic treatment. The specific reasons for the relationship between LDL cholesterol and the triglycerides at fasting status are still unclear. However, this result is partly consistent with a previous study, in which the relationship between triglycerides and coronary heart disease became independent in participants with lower LDL cholesterol levels [4]. Thus, future studies are warranted to investigate the mechanism further.

The major advantage of present study is that we included a large sample size, which had greatly ensured the reliability of the results. In addition, the participants of our study are representative of the general population as the subjects of our study were collected from the general U.S. community.

Our study is limited mainly due to the fact that this is a cross-sectional study, in which food intake before blood draw was not controlled. Further, as mentioned above, we did not collect the data of food intake before blood draw. This may cause potential bias of our results. The participants of our study were generally young subjects. Thus, the results may not be generalizable to old subjects. Further, as mentioned above, interaction test is a low-power test. Although the significance cut point was set at 0.10, we may still not able to capture some potential CVD risk factors that had an influence on the difference between fasting and non-fasting triglycerides. Lastly, non-fasting and fasting participants are not matched on factors such as age, BMI, total fat intake, smoking status. As shown in Table 1, participants who provided fasting samples were significantly older, had higher BMI and total fat intake, and had more current smokers. All these factors could increase triglyceride levels, which could bias the results towards the null. Therefore, if these factors were similar between two groups, we would possibly detect a larger magnitude of differences of triglycerides. This evidence indirectly supports that our results are robust as the real difference between non-fasting and fasting triglycerides may be much larger than that was observed in our study. In addition, matching is not a wise option for the present study as this will dramatically reduce the sample size and power of our study. Two major reasons are responsible for this: the sample size was comparable between two groups and the difference between two groups was relatively large. Finally, LDL level was calculated, which may bias our results.

Conclusions

We have shown that the overall difference between fasting and non-fasting triglycerides was 4 mg/dL. However, in the separate analyses of the participants with and without hypertension, antihyperlipidemic agent use or with high and low levels of LDL cholesterol, the average range of difference between fasting and non-fasting triglycerides was 6-14 mg/dL in participants with hypertension, antihyperlipidemic agent use or low LDL cholesterol levels, respectively. In these scenarios, non-fasting triglycerides may be more useful than fasting triglycerides to predict future CVDs. According to the clinical guideline on normal and high triglycerides, the relatively small difference between fasting and non-fasting triglycerides found in our study is unlikely has a large influence on the correct distinction between these two categories. However, it does not mean that the small difference between fasting and non-fasting triglycerides will not have an influence on their prediction on CVDs. Actually, the average different of triglycerides between participants with and without incident coronary heart disease is only 15-19 mg/dL, and many individuals have normal triglycerides (according to clinical guideline) before the occurrence of coronary heart disease [19,20]. Thus, the prediction of CVDs may be influenced by the magnitude of the difference between fasting and non-fasting triglycerides, which can be 14 mg/dL among certain participants. Certainly, due to the nature of observational and cross-section design, results of our study warrant further confirmation in intervention and

prospective studies. Future prospective studies to compare the predictive values between fasting and non-fasting triglycerides among participants with hypertension, antihyperlipidemic agent use or low LDL cholesterol levels are especially worthwhile.

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