Body Composition Measures Associated with Postprandial Triglyceride Concentrations

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Abstract

Background
A large increase in triglyceride (TG) concentrations following a high-fat meal (i.e., postprandial lipemia) is an independent cardiovascular disease (CVD) risk factor. However, little is known regarding individual factors that are associated with or determine postprandial triglycerides (PPTGs). We aimed to identify body composition measures that are associated with PPTG concentrations following a high-fat meal.

Methods
We conducted a secondary analysis of data from five previously conducted studies in our laboratory, each utilizing identical methods of data collection. PPTGs were measured at baseline and 4 hours after a high-fat shake (73% fat; 9kcal/kg). In addition to body mass index (BMI) and waist circumference (WC), body composition variables – relative body fat (BF%), relative muscle mass (MM%), and visceral adipose tissue (VAT) – were measured via bioelectrical impedance.

Results
Across five studies, complete data from 156 participants (age: 44.9 ± 21.0 years; sex: 83F/73M; BMI: 27.3 ± 5.5 kg/m^2; fasting glucose: 98.6 ± 7.8 mg/dL; fasting TG: 94.6 ± 45.3 mg/dL; fasting total cholesterol: 170.8 ± 34.5 mg/dL) were compiled for this secondary analysis. PPTGs were correlated with age ($r = 0.24$, $p = 0.003$) but no difference between sexes was observed ($p = 0.06$). Significantly associated with 4-hr TG were BMI ($r = 0.29$, $p < 0.0001$), WC ($r = 0.33$, $p < 0.0001$), BF% ($r = 0.23$, $p = 0.004$), MM% ($r = 0.23$, $p = 0.004$), and VAT ($r = 0.35$, $p < 0.0001$). In a backward elimination regression ($r^2 = 0.15$), the variables most predictive of 4-hr TG were MM% ($\beta = 0.21$, $p = 0.009$), VAT ($\beta = 0.25$, $p = 0.004$), and BF% ($\beta = 0.16$, $p = 0.064$).

Conclusions
In a secondary analysis of 156 participants across five studies, we identified MM%, VAT, and BF% as being the most predictive of 4-hr TG. Although the strength of the relationship may be weak to moderate, body composition appears to influence PPTGs in healthy younger to middle-aged adults. Further research could determine preventative measures targeting body composition to lower the risk of cardiovascular disease associated with PPTGs.

Background

Cardiovascular disease (CVD) has consistently topped the charts as the leading cause of mortality in the U.S., with over 600,000 deaths reported in 2020 [1]. According to the CDC, daily habit modifications that promote a healthy lifestyle can help lower modifiable CVD risk factors [2]. Currently, research has identified high blood pressure, cigarette use, diabetes mellitus, and abnormal lipid levels as major modifiable risk factors associated with CVD with about half (47%) of the US population having at least one risk factor [3, 4]. Obesity has been determined an independent CVD risk factor and is a condition that often encompasses each of the modifiable risk factors previously listed [5].

Triglycerides (TG) are a useful metabolic marker that have been associated with CVD events [6]. Specifically, postprandial triglycerides (i.e. triglycerides after a high-fat meal) have been shown to be a strong indicator of cardiovascular risk [7-8]. In a secondary analysis by Bansal et al., in a population of healthy women, PPTGs were associated with CVD risk [7]. Moreover, TG levels measured 2 to 4 hours post-meal were associated with the highest correlation with CVD events [7].

Given that obesity is a central component to cardiometabolic disease, it is important to explore the impact of body composition on metabolic health. Little is known regarding body composition factors that are associated with or determine postprandial triglycerides (PPTGs) [9-10]. The purpose of this secondary analysis was to identify body composition measures that are most associated with PPTG concentrations following a high-fat meal. We hypothesized that there would be a strong correlation between body composition measures (age, BMI, WC, BF%, MM%, VAT, and sex) and a change in triglyceride levels.

Methods

Participants

Data from five studies in our laboratory were compiled, totaling 156 participants (age: 44.9 ± 21.0 years). The screening and data collection methods were identical across the studies [11, 12, 13]. The sex distribution of participants was 83 females (F) and 73 males (M). An abbreviated fat tolerance test (AFTT) was used to determine PPTG. For this test, TG levels were measured at baseline and then participants were fed a high fat shake (73% fat; 9kcal/kg). Postprandial TG levels were then measured 4 hours later.

Screening Procedures

Participants across the five studies were recruited via flyers, mass email, and word of mouth at Oklahoma State University on the Stillwater campus. Participants completed a basic medical history questionnaire. Exclusion criteria were identical across the 5 studies. Individuals were excluded if any of the following were present: a known cardiometabolic condition (e.g., CVD), an inflammatory disease (e.g., inflammatory bowel disease), use of tobacco products, use of illegal drugs, use of lipid-lowering drugs, and/or being postmenopausal. After passing these preliminary screening procedures for eligibility, participant BMI, waist circumference (WC), relative body fat (BF%), relative muscle mass (MM%), visceral adipose tissue (VAT), and blood pressure were measured.

Bioelectrical Impedance

BF%, MM%, and VAT were obtained using bioelectrical impedance analysis (BIA) measurement. BIA allows ascertainment of fat-free mass and total body water in participants which may then be used for additional body composition variable calculations [14]. Seca mBCA 514 was used for calculating body composition variables through BIA and has been validated

[15]. Seca mBCA 514 utilizes 8-point BIA to obtain body composition measurements [15]. Participants stand with feet and hands on electrodes for approximately 30 seconds as BIA is conducted [15].

Abbreviated Fat Tolerance Test

An abbreviated fat tolerance test (AFTT) was administered to participants across all five studies. A fasting blood draw was obtained using single venipuncture into a lithium heparin vacutainer [16]. TGs were measured using a Piccolo Xpress clinical chemistry analyzer with Lipid Panel Plus cassettes [16]. Following the fasting blood draw, participants were fed a high-fat shake in a 20-minute timeframe. The composition of the shake was approximately 73% fat with 9 kcal/kg and consisted of coconut cream, pea protein powder and chocolate syrup [16]. Participants were then permitted to leave the laboratory to return four hours later. Participants were instructed not to consume anything of caloric value within that time. Additionally, no physical exertion was permitted within that time outside of common daily activities. At participant return, a 4-hour blood draw was obtained to measure change in PPTGs. The AFTT has been demonstrated to be both valid [17] and reliable [12].

Statistical Analyses

Differences between female and male characteristics were determined using unpaired *t* tests. Pearson correlations were used to determine associations between body composition variables and PPTGs. A backwards linear regression was utilized to identify variables most related to change in TG. All data were analyzed in SPSS and are presented as the mean ± SD.

Results

Participant Characteristics

Table 1. Participant Characteristics

	Combined (n = 156)	Female (n = 83)	Male (n = 73)
Participant Characteristics			
Age (years)	44.9 ± 21.0	44.8 ± 21.3	44.9 ± 20.9
Height (cm)	170.4 ± 10.5	164.0 ± 7.6	177.8 ± 8.2
BMI (kg/m^2)	27.3 ± 5.5	26.6 ± 5.9	28.1 ± 4.9
WC (inches)	25.7 ± 5.9	33.5 ± 5.5	38.0 ± 5.3
Body Fat (%)	33.2 ± 10.2	37.5 ± 10.0	28.5 ± 8.2
Muscle Mass (%)	43.6 ± 15.8	39.6 ± 14.1	48.0 ± 16.4
VAT (L)	2.2 ± 1.8	1.4 ± 1.0	3.0 ± 2.1
Fasting Total-C (mg/dL)	170.8 ± 34.5	177.1 ± 31.3	163.7 ± 36.8
Fasting Glucose (mg/dL)	98.6 ± 7.8	97.5 ± 7.0	99.8 ± 8.5
Fasting Triglycerides (mg/dL)	94.6 ± 45.3	89.1 ± 30.6	100.9 ± 57.3
Fasting LDL (mg/dL)	94 ± 28.7	95.1 ± 26.1	92.8 ± 31.4
Fasting VLDL (mg/dL)	18.8 ± 9.1	17.5 ± 6.2	20.3 ± 11.4
Fasting HDL (mg/dL)	56.8 ± 12.8	62.2 ± 10.8	50.8 ± 12.2
ALT (U/L)	28 ± 11.7	25.6 ± 9.4	30.5 ± 13.5
AST (U/L)	28.6 ± 7.7	28.1 ± 8.1	29.2 ± 7.3

Data are presented as mean ± SD. Abbreviations: **BMI** body mass index; **WC** waist circumference; **VAT** visceral adipose tissue; **Total-C** total cholesterol; **LDL** low-density lipoprotein; **VLDL** very low-density lipoprotein; **HDL** high-density lipoprotein; **ALT** alanine aminotransferase; **AST** aspartate aminotransferase.

Participant Characteristics are displayed in **Table 1.** Across five studies, complete data from 156 participants were compiled for this secondary analysis. Participants are split into female and male category to allow easier differentiation between sex-oriented body composition variance.

Correlations between Body Composition and Postprandial Triglycerides

Body composition variables significantly associated with PPTGs were BMI ($r = 0.29$, $p < 0.0001$), WC ($r = 0.33$, $p < 0.0001$), BF% ($r = 0.23$, $p = 0.004$), MM% ($r = 0.23$, $p = 0.004$), and VAT ($r = 0.35$, $p < 0.0001$). PPTGs were also correlated with age ($r = 0.24$, $p = 0.003$, **Figure 1**) but no differences between sexes was observed ($p = 0.06$). In a backward elimination regression ($r^2 = 0.15$), the variables most predictive of PPTGs were MM% ($\beta = 0.21$, $p = 0.009$, **Figure 2**), VAT ($\beta = 0.25$, $p = 0.004$, **Figure 3**), and BF% ($\beta = 0.16$, $p = 0.064$, **Figure 4**) each depicted in orange.

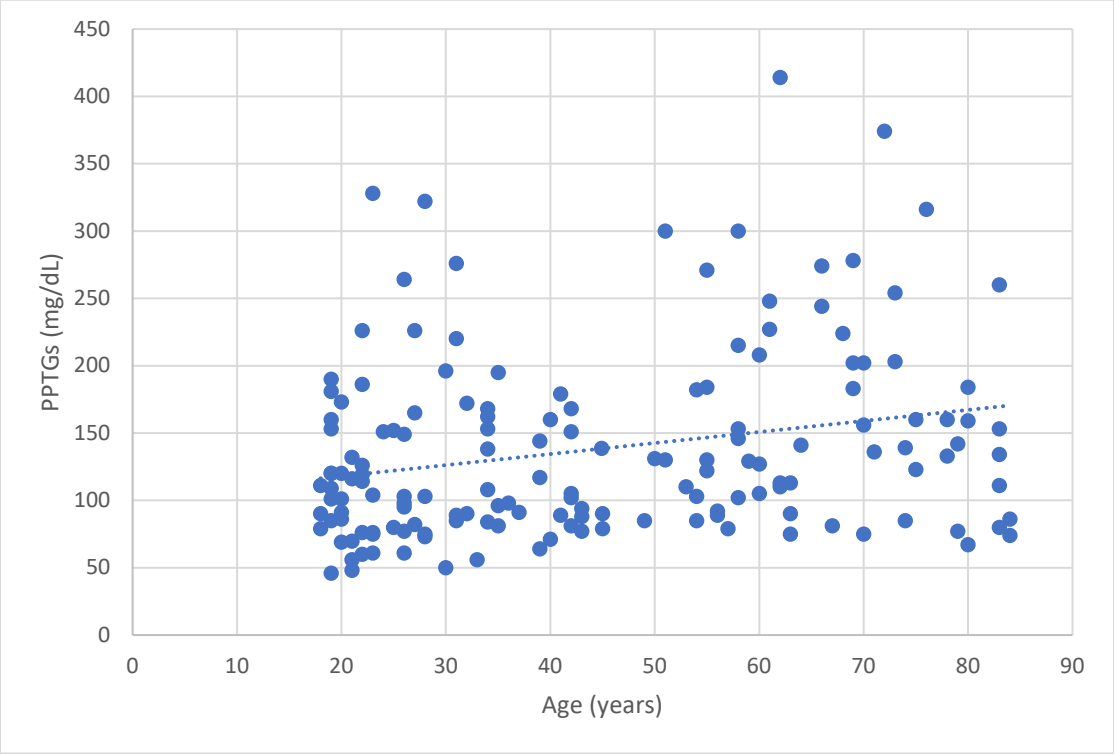

Figure 1. Correlation between PPTGs (mg/dL) vs. Age (years). Each data point represents a single participant. **PPTGs** postprandial triglycerides.

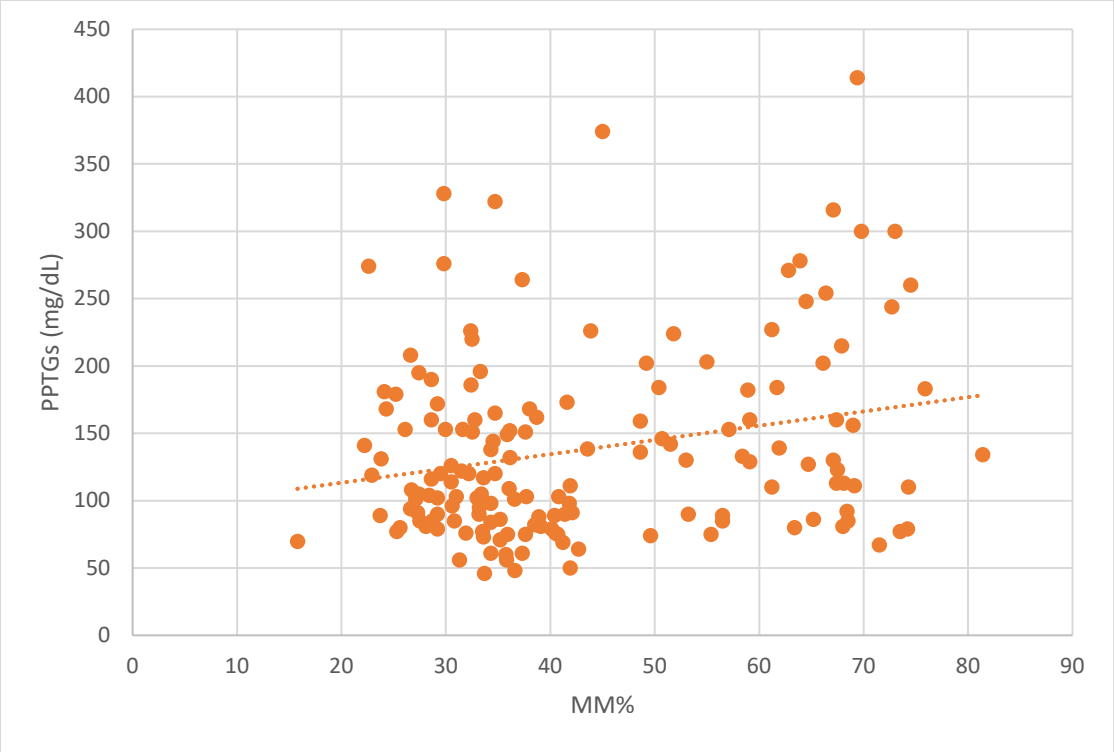

Figure 2. Correlation between PPTGs (mg/dL) vs. MM%. Each data point represents a single participant. **PPTGs** postprandial triglycerides; **MM%** relative muscle mass.

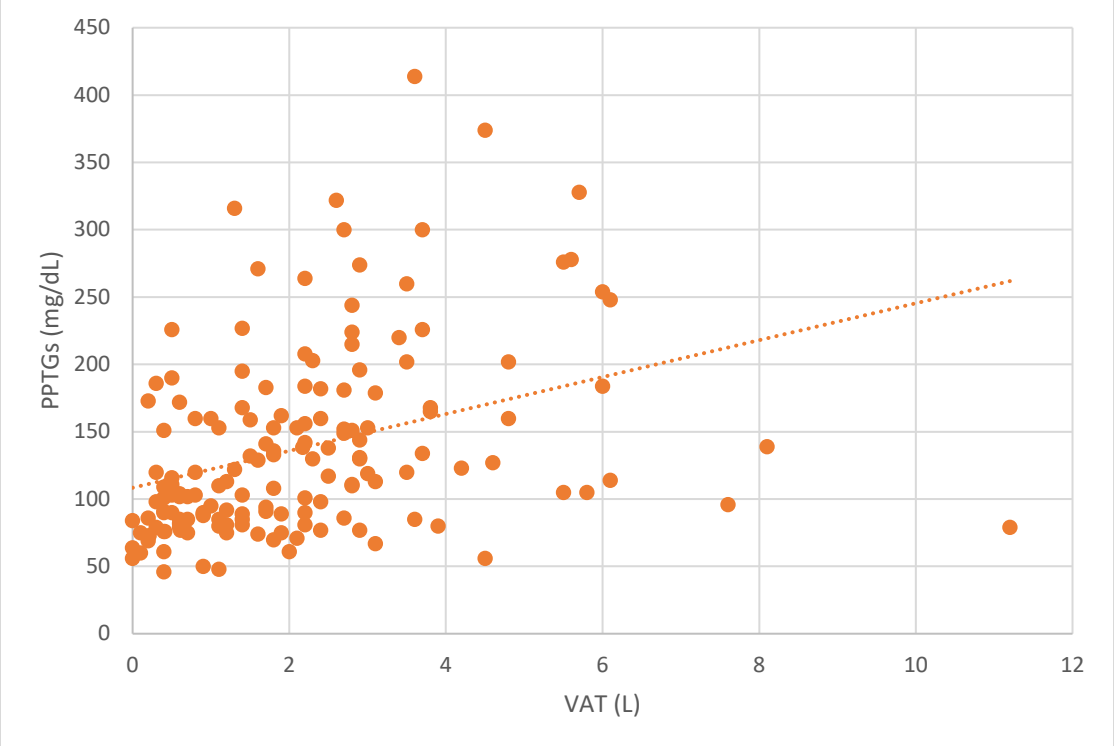

Figure 3. Correlation between PPTGs (mg/dL) vs. VAT (L). Each data point represents a single participant. **PPTGs** postprandial triglycerides; **VAT** visceral adipose tissue.

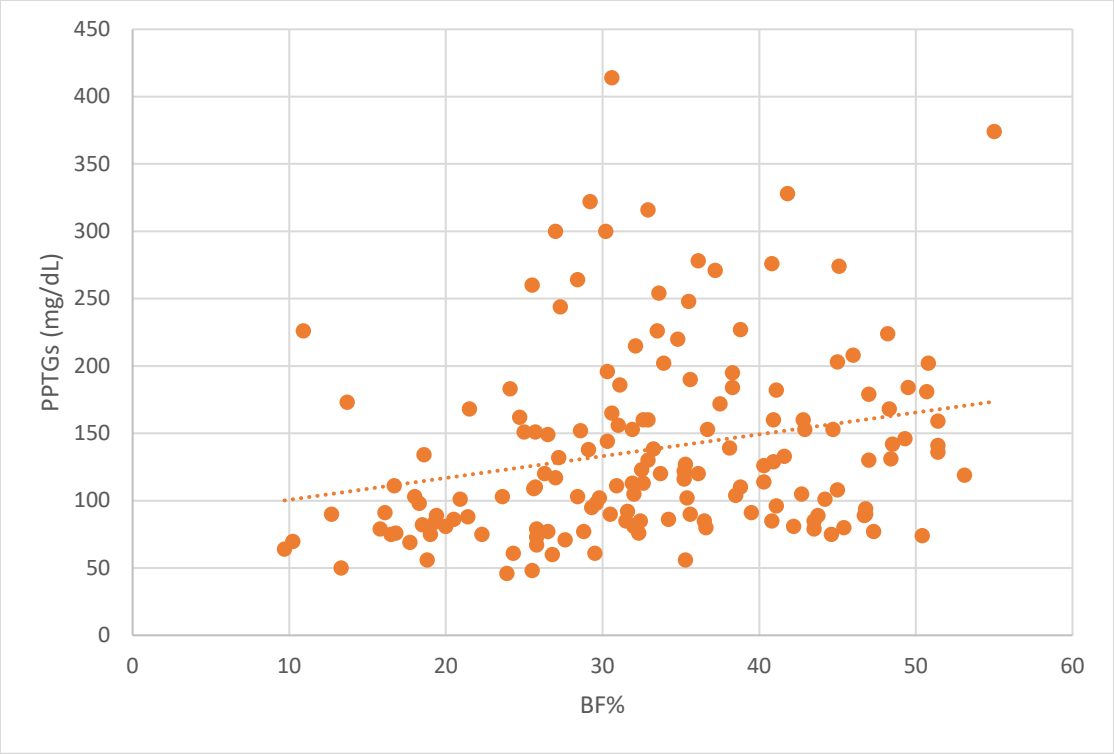

Figure 4. Correlation between PPTGs (mg/dL) vs. BF%. Each data point represents a single participant. **PPTGs** postprandial triglycerides; **BF%** relative body fat.

Conclusions

Main Findings

Elevated PPTGs are a known independent CVD risk factor. However, few studies have been conducted to observe variables correlated with a change in PPTGs [9-10]. The purpose of this study was to identify body composition measures that are most associated with PPTG concentrations following a high-fat meal. We hypothesized that there would be a strong correlation between our body composition measures (age, BMI, WC, BF%, MM%, VAT, and sex) and a change in triglyceride levels. Through statistical analysis, we determined that age, BMI, WC, BF%, MM%, and VAT were all significantly associated 4-hour PPTGs, albeit weak to moderate in nature. Interestingly, sex was not significantly associated with a change in

PPTGs. Through a backward elimination regression, we determined MM%, VAT, and BF% to be most predictive of PPTG.

Body Composition and Postprandial Triglycerides

Our data shows that MM% is closely correlated with a change in PPTG levels. As previously mentioned, few studies specifically assess body composition variables (e.g., MM%) against PPTGs. Interestingly, a recent study from 2021 indicated that MM% was not correlated with PPTGs [18]. As depicted in **Figure 2**, our results show increasing MM% is weakly correlated with an increase in PPTGs. However, the 2021 study consisted of 2,487 children and adolescents (age 8-19 years) [18]. The inconsistency may be due to an age-related metabolic difference.

Regarding our results on VAT, a few studies were available to compare directly. Significantly, a study published in 1999 noted that VAT is correlated with PPTGs in both males and females [9]. Additionally, a 2018 epigenetic study utilized VAT sampling to analyze PPTG concentrations in individuals with Metabolic Syndrome (MetS) [19]. In the study from 2018, researchers utilized VAT, which we determined to be correlated with PPTGs, to determine effect on lipoprotein lipase (LPL) gene methylation [19]. Interestingly, LPL promoter methylation in VAT was higher in MetS subjects over subjects without MetS [19]. Methylation of the LPL promoter region would lead to inexpression of this fat-constructing enzyme. A loss of function of the LPL gene would then result in elevation of PPTGs. This conservatively provides an explanation for our results. **Figure 3** depicts a weak positive correlation between increasing VAT and increasing PPTGs.

Our results regarding BF% are consistent with research conducted in 2008. This study noted that in a population of males diurnal (e.g., during the day) TG are associated with fat mass

and proposed that diurnal TG profiles be an additional tool in determining CVD risk [20]. While not specifically diurnal, in **Figure 4**, our data indicates a weak correlation between BF% and PPTGs.

Our study strengths include a relatively large sample size (n = 156) allowing for adequate power to detect PPTG correlates. Additionally, the data was collected out of the same lab allowing for greater consistency in procedures and collection methods. Limitations of our study include the various study designs employed to gather data across the five studies included in this analysis. Inherent limitations unique to each design may contribute to any weakness in this secondary analysis.

Conclusions and Future Directions

Our primary findings determined MM%, VAT, and BF% to be most predictive of PPTG. Further research could isolate specific age-ranges to analyze body composition effects on PPTG changes. Additionally, future studies could seek to determine favorable routines to achieve ideal body composition to lower the risk of cardiovascular disease associated with postprandial triglycerides.

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Conflicts of interest: No conflicts of interest to disclose.

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