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Letter to the Editors

Are abdominal obesity and body mass index independent predictors of hemorheological parameters?

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There is an association between obesity and rheological blood behavior [2, 4–7]. In this sense we have read with interest the recently published article by Brun et al. [1] in this journal. The authors evaluate, in a population of 430 subjects, the relationship between abdominal obesity and body mass index (BMI) with blood viscosity, and conclude that both anthropometric parameters are associated with increased blood viscosity but by different mechanisms, where the waist to hip ratio is a better predictor for blood viscosity than BMI.

It is striking that in this study the authors do not indicate the variables included in the stepwise multivariate regression model, where plasma lipids, glucose and fibrinogen do not seem to have been included, being important from a rheological point of view. It seems that only the waist to hip ratio (WHR) and BMI were taken into account as predictors of blood viscosity.

In order to clarify this issue and to know not only the relationship between the above mentioned anthropometric parameters with blood viscosity, but also with the rest of hemorheological variables (i.e. corrected blood viscosity at 45% hematocrit, plasma viscosity, erythrocyte aggregation and erythrocyte deformability), we analyzed the association of BMI and waist circumference with hemorheological parameters, and also with glucose, plasma lipids and fibrinogen in 395 healthy subjects (199 males/196 females, aged: 44.13 ± 12.61). We preferred to use waist circumference rather than WHR because it seems to be a stronger predictor of cardiovascular risk [3].

Anthropometric, lipidic, fibrinogen and hemorheological parameters were determined as previously [9]. A multivariate regression analysis was performed to explore the association of native blood viscosity, corrected blood viscosity, plasma viscosity, erythrocyte aggregation and erythrocyte deformability

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Table 1
Pearson's correlations among variables

	Native blood viscosity 230 s^{-1} ($n = 375$)	Corrected blood viscosity 230 s^{-1} ($n = 375$)	Plasma viscosity ($n = 395$)	Erythrocyte aggregation 3 s^{-1} ($n = 395$)	Elongation index 60 Pa ($n = 382$)
BMI	0.165**	0.016	0.193***	0.211***	−0.212***
Waist circumference	0.319***	0.025	0.137**	0.214***	−0.223***
Glucose	0.131*	0.094	0.055	0.176***	−0.084
Total-cholesterol	0.112*	0.015	0.131**	0.240***	−0.080
Triglycerides	0.190***	0.009	0.167**	0.225***	−0.140**
Fibrinogen	0.042	0.160*	0.385***	0.382***	−0.120*
Hematocrit	0.719***	0.083	0.127*	0.191**	−0.133*
MCV	0.074	0.004	0.073	0.199***	−0.207***
MCH	0.197**	0.031	0.060	0.249***	−0.098

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 2
Beta coefficients obtained in the multivariate regression analysis including waist circumference in the model

	Native blood viscosity 230 s^{-1} ($n = 375$)	Corrected blood viscosity 230 s^{-1} ($n = 375$)	Plasma viscosity ($n = 395$)	Erythrocyte aggregation 3 s^{-1} ($n = 395$)	Elongation index 60 Pa ($n = 382$)
Waist circumference	0.002	−0.001	0.0001	0.005	−0.048*
Glucose	−0.001	0.002	−0.0002	0.010	−0.002
Total-cholesterol	−0.0003	−0.0001	0.0001	0.003*	−0.004
Triglycerides	0.0001	−0.0002	0.0002**	0.004**	−0.004
Fibrinogen	−0.0001	0.001***	0.0003***	0.007***	−0.002
Elongation index	−0.017*	−0.005			
Hematocrit	0.094***				
MCV				−0.003	0.294**
MCH				0.165**	−0.340

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

(dependent variables) with BMI, waist circumference, glucose, total-cholesterol, triglycerides, hematocrit, VCM, HCM and fibrinogen (independent variables) in accordance with the relationships obtained in the Pearson's bivariate correlation. BMI and waist circumference showed collinearity (tolerance = 0.29; $r = 0.786$ $p < 0.001$) so they have been included separately in two multivariate regression models for each dependent variable.

Table 1 shows the crude Pearson's bivariate correlation among the variables. Table 2 and Table 3 show the beta coefficients of the predictors of the hemorheological parameters analyzed including in the model waist circumference (Table 2) and BMI (Table 3).

Our results indicate that regarding both anthropometric parameters in a healthy population, only abdominal obesity (waist circumference) is an independent predictor for erythrocyte elongation index, as previously shown in morbidly obese subjects [8]. BMI was not found to be an independent predictor

Table 3
Beta coefficients obtained in the multivariate regression analysis including BMI in the model

	Native blood viscosity 230 s^{-1} ($n = 375$)	Corrected blood viscosity 230 s^{-1} ($n = 375$)	Plasma viscosity ($n = 395$)	Erythrocyte aggregation 3 s^{-1} ($n = 395$)	Elongation index 60 Pa ($n = 382$)
BMI	−0.003	−0.008	0.001	0.015	−0.093
Glucose	−0.001	0.003	−0.0003	0.010	−0.030
Total-cholesterol	−0.0003	−0.0002	0.0001	0.003*	−0.002
Triglycerides	0.0003	−0.0002	0.0001**	0.004**	−0.006
Fibrinogen	−0.0001	0.001**	0.0003***	0.007***	0.002
Elongation index	−0.020**	−0.006			
Hematocrit	0.096***				
MCV				−0.004	0.314**
MCH				0.170**	−0.400

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

for any of the rheological variables studied. BMI and waist were not independent predictors for native blood viscosity. Only hematocrit and erythrocyte elongation index predict this variable. The association of blood viscosity with BMI and WHR observed by Brun et al. [1] may be a confounding effect for not having included all the relevant mentioned variables in the model.

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