Association of mean corpuscular volume with sarcopenia and visceral obesity in individuals without anemia

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ABSTRACT

Aims/Introduction: Sarcopenia and visceral obesity are major global public health issues, and higher mean corpuscular volume (MCV) levels are related to adverse outcomes. Nevertheless, no study has determined the association between MCV and body composition. Therefore, we evaluated the association between MCV levels and trunk muscle quality, muscle quantity and visceral fat area.

Materials and Methods: In our cross-sectional study, we investigated 702 middle-aged Japanese individuals without anemia and with normal MCV levels who underwent physical checkups. The cross-sectional area of skeletal muscle or visceral fat was analyzed by computed tomography.

Results: In the adjusted model, the MCV was independently associated with the visceral fat area index (β = −0.107, P = 0.0007), total skeletal muscle index (β = 0.053, P = 0.0341) and total skeletal muscle density (β = 0.099, P = 0.0012). MCV as a continuous variable was related to the prevalence of sarcopenia (odds ratios [OR] 0.93, 95% confidence intervals (CI) 0.88–0.98, per 1.0 fL increment; P = 0.0097) and visceral obesity (OR 0.91, 95% CI 0.86–0.97, per 1.0 fL increment; P = 0.0046). The highest MCV quartile was independently associated with the prevalence of sarcopenia (OR 0.48, 95% CI 0.27–0.83; P = 0.0089) and visceral obesity (OR 0.49, 95% CI 0.27–0.88; P = 0.0170), compared with the lowest quartile.

Conclusions: In individuals without anemia and with normal MCV levels, a lower MCV was associated with unfavorable body composition, including lower muscle quality, lower muscle quantity, sarcopenia and visceral obesity.

INTRODUCTION

Unfavorable body composition changes with aging include sarcopenia, characterized by muscle loss and decline in muscular strength, and body fat accumulation leading to obesity1. These are related to metabolic deteriorations and physical impairment, and contribute to adverse outcomes2. Sarcopenia often accompanies obesity and leads to a specific condition known as sarcopenic obesity3. Individuals with sarcopenic obesity might have more metabolic impairments and an elevated risk of mortality than sarcopenia or obesity alone4.

Mean corpuscular volume (MCV) is a capacity of the mean size of red blood cells (RBCs), and is associated with mortality and morbidity5,6. In particular, some studies have shown that macrocytosis is associated with adverse outcomes5,7,8.

No survey on the association between MCV and body composition is currently available in the literature. Given previous findings, we hypothesized that a higher MCV would be associated with unfavorable body composition, such as sarcopenia and obesity. Therefore, we analyzed the relationship between MCV and body composition parameters, including trunk muscle quality and quantity, and visceral fat area (VFA) by computed tomography (CT). As CT can classify skeletal muscle into areas of intermuscular adipose tissue (IMAT), normal-attenuation muscle (NAM) and low-attenuation muscle (LAM), we also analyzed whether the MCV was associated with IMAT, NAM and LAM. The present study aimed to investigate whether MCV levels were associated with muscle quality,
muscle quantity, unfavorable body composition, sarcopenia and visceral obesity in middle-aged Japanese individuals without anemia and with normal MCV levels.

METHODS

Study design
The Nishimura Health Survey has been described previously. We carried out a cross-sectional analysis to investigate MCV and body composition parameters. From 20,852 individuals who received physical checkups from 1 April 2013 to 31 March 2018, 830 individuals had an abdominal CT scan. The CT is not included in the basic examination items; however, it can be carried out on request. We excluded two individuals in whom at least one variable was not assessed. From the remaining 828 individuals, we excluded 20 individuals with a history of malignant disease or high C-reactive protein (CRP) levels >95.2 nmol/L (10.0 mg/L), because such elevated levels might be related to active infection or systemic inflammatory processes. We also excluded five individuals who had indicators of renal dysfunction (defined based on thresholds of serum creatinine of 106.1 µmol/L for men and 88.4 µmol/L for women), 75 individuals with anemia (defined based on thresholds of hemoglobin 130.0 g/L for men and 120.0 g/L for women) and 26 individuals without normal MCV levels (defined based on thresholds of MCV <80 and >100 fL), because kidney dysfunction, vitamin B12 and iron deficiency affect erythropoiesis. Finally, 702 individuals were competent for the present study.

All procedures were approved by the local research ethics committee of Kyoto Prefectural University of Medicine (ERB-C-1017-1), and carried out in accordance with the Declaration of Helsinki. Informed consent was obtained from all study participants.

Data measurements
Demographic data and biomarkers were investigated, as described previously.

CT
Evaluation of skeletal muscle area, skeletal muscle density (SMD) and VFA were carried out, as previously described.

Definitions
The study participants were classified by sex, and divided into four subgroups according to MCV quartiles: the cut-off quartile levels for men were 88.62, 91.349 and 93.74 fL, whereas those for women were 87.58, 89.92 and 92.15 fL, respectively.

Diabetes mellitus was defined according to the criteria recommended by the American Diabetes Association, in addition to a medical history of diabetes. Prediabetes was defined as a fasting blood glucose level from 100 to 125 mg/dL (5.6–7.0 mmol/L). Hypertension was defined as a systolic blood pressure >140 mmHg or diastolic blood pressure >90 mmHg, in addition to a medical history of hypertension. Dyslipidemia was defined as either or a combination of low-density lipoprotein cholesterol ≥4.14 mmol/L, high-density lipoprotein cholesterol <1.03 mmol/L or triglycerides ≥1.69 mmol/L, in addition to a medical history of dyslipidemia.

The cross-sectional areas by CT scan were standardized for body mass index (BMI; cm²/(kg/m²)) and, as described as the skeletal muscle index (SMI), NAM index, LAM index, VFA index and IMAT index. Sarcopenia was defined as SMI one standard deviation below the sex-specific mean level for young adults (18–40 years). In the present study, the cut-off levels were 6.06 cm²/(kg/m²) for men and 4.35 cm²/(kg/m²) for women. Visceral obesity was defined as a VFA ≥100 cm² according to the Japanese visceral obesity criteria. Sarcopenic obesity was defined as a combination of obesity and sarcopenia, as defined by the International Obesity Task Force.

Statistical analysis
We used one-way analysis of variance (ANOVA) and the χ²-test. Multiple regression analyses were carried out to determine the associations between MCV and several muscle parameters or the VFA index. Multivariate logistic regression analyses were carried out to determine the association between erythrocyte indices as a continuous variable or quartiles, and the prevalence of sarcopenia, visceral obesity and sarcopenic obesity after controlling for confounding factors. The following parameters were determined as potential covariates: model 1, adjusted by age and sex; model 2, adjusted by model 1 covariates plus smoking status, drinking status and exercise status; model 3, adjusted by model 2 covariates plus the prevalence of hypertension, dyslipidemia, diabetes mellitus, albumin, estimated glomerular filtration rate and CRP levels; and model 4, adjusted by model 3 covariates plus hemoglobin level. We divided the participants into three groups: normal, prediabetes and diabetes; and subgroup analyses were carried out. We used JMP version 11.0 software (SAS Institute Inc., Cary, NC, USA) for statistical analyses.

RESULTS
The characteristics of the 702 participants (462 men and 240 women) are shown in Table 1. There was a significant difference across MCV quartiles in terms of age (P < 0.0001), BMI (P < 0.0001), regular exercise (P = 0.0002), alcohol consumption (P < 0.0001), current smoker (P = 0.0021), estimated glomerular filtration rate (P = 0.0018) and CRP levels (P = 0.0016). There was no significant difference across the MCV quartiles in terms of VFA index, IMAT index, total SMI, NAM index, LAM index and total SMD, as well as the prevalence of sarcopenia, visceral obesity and sarcopenic obesity.

The results of multiple regression analyses are shown in Table 2. In model 4, MCV was independently associated with the VFA index (β = −0.107, P = 0.0007), total SMI (β = 0.053, P = 0.0341), NAM index (β = 0.061, P = 0.0166) and total SMD (β = 0.099, P = 0.0012).

Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) of MCV levels for the prevalence of sarcopenia, visceral
Table 1 | Clinical characteristics of the study participants according to the mean corpuscular volume quartiles

|                | Q1       | Q2       | Q3       | Q4       | P-value |
|----------------|----------|----------|----------|----------|---------|
| n              | 175      | 175      | 176      | 176      |         |
| Age (years)    | 46.6 ± 9.8 | 51.2 ± 10.4 | 52.4 ± 10.5 | 53.8 ± 10.3 | <0.0001 |
| Men            | 115 (65.7) | 115 (65.7) | 116 (65.9) | 116 (65.9) | 1.0000  |
| Body mass index (kg/m²) | 24.1 ± 4.4   | 23.4 ± 3.9   | 22.6 ± 3.1   | 22.4 ± 3.1   | <0.0001 |
| Regular exercise | 27 (15.4)  | 46 (26.3)  | 61 (34.7)  | 56 (31.8)  | 0.0002  |
| Alcohol drinking habit | 10 (5.7)   | 31 (17.7)  | 44 (25.0)  | 61 (34.7)  | <0.0001 |
| Current smoker | 23 (13.1)  | 20 (11.4)  | 36 (20.5)  | 44 (25.0)  | 0.0021  |
| Ex-smoker      | 40 (22.9)  | 50 (28.6)  | 40 (22.7)  | 48 (27.3)  | 0.4721  |
| Hypertension   | 46 (26.3)  | 41 (23.4)  | 54 (30.7)  | 54 (30.7)  | 0.3443  |
| Dyslipidemia   | 48 (27.4)  | 47 (26.9)  | 43 (24.4)  | 42 (23.9)  | 0.8361  |
| Diabetes mellitus | 14 (8.0)  | 15 (8.6)  | 16 (9.1)  | 7 (4.0)    | 0.2425  |
| Albumin (g/L) | 45.0 ± 2.8 | 45.1 ± 2.7 | 45.3 ± 2.2 | 44.8 ± 2.6 | 0.3161  |
| Estimated glomerular filtration rate (mL/min/1.73 m²) | 80.1 ± 14.3 | 76.9 ± 12.0 | 76.0 ± 12.1 | 75.2 ± 11.9 | 0.0018  |
| C-reactive protein level (in mmol/L) | 9.4 ± 14.0 | 9.4 ± 13.2 | 6.1 ± 8.0 | 6.6 ± 11.3 | 0.0016  |
| White blood cell count (x10⁹/L) | 5.79 ± 1.40 | 5.70 ± 1.72 | 5.58 ± 1.42 | 5.46 ± 1.65 | 0.2153  |
| Red blood cell count (x10¹²/L) | 5.0 ± 0.4 | 4.8 ± 0.3 | 4.7 ± 0.3 | 4.6 ± 0.3 | <0.0001 |
| Hemoglobin (g/L) | 143.3 ± 12.2 | 142.9 ± 11.4 | 141.7 ± 11.5 | 143.5 ± 11.6 | 0.4753  |
| Hematocrit (%) | 43.5 ± 3.3 | 43.4 ± 3.0 | 43.0 ± 3.1 | 43.7 ± 3.1 | 0.2652  |
| Mean corpuscular volume (fl) | 86.3 ± 1.6 | 89.7 ± 0.9 | 91.9 ± 1.0 | 95.3 ± 1.7 | <0.0001 |
| Mean corpuscular hemoglobin (pg/cell) | 28.4 ± 0.9 | 29.6 ± 1.0 | 30.2 ± 0.9 | 31.3 ± 1.2 | <0.0001 |
| Mean corpuscular hemoglobin concentration (g/L) | 329.2 ± 8.6 | 329.5 ± 9.6 | 329.1 ± 8.2 | 328.5 ± 10.7 | 0.8080 |
| Visceral fat area index (cm²/kg/m²) | 4.2 ± 2.4 | 4.0 ± 2.3 | 4.0 ± 2.3 | 3.8 ± 2.3 | 0.3908 |
| IMAT index (cm²/kg/m²) | 0.09 ± 0.10 | 0.09 ± 0.09 | 0.11 ± 0.09 | 0.10 ± 0.09 | 0.3696 |
| Total SMI (cm²/kg/m²) | 5.7 ± 1.2 | 5.8 ± 1.3 | 5.7 ± 1.1 | 5.8 ± 1.1 | 0.8520 |
| NAM index (cm²/kg/m²) | 4.3 ± 1.4 | 4.3 ± 1.4 | 4.2 ± 1.2 | 4.3 ± 1.2 | 0.9615 |
| LAM index (cm²/kg/m²) | 1.4 ± 0.4 | 1.5 ± 0.4 | 1.4 ± 0.4 | 1.5 ± 0.4 | 0.1759 |
| Total SMD (HU) | 42.3 ± 7.1 | 42.3 ± 7.3 | 42.1 ± 6.5 | 42.2 ± 7.0 | 0.9838 |
| Sarcopenia | 67 (38.3) | 68 (38.9) | 69 (39.2) | 53 (30.1) | 0.2305 |
| Visceral obesity | 88 (50.3) | 78 (44.6) | 74 (42.1) | 72 (40.9) | 0.2933 |
| Sarcopenic obesity | 50 (28.6) | 36 (20.6) | 44 (25.0) | 36 (20.5) | 0.2178 |

For men, quartile (Q1): <88.62; Q2: 88.62–91.349; Q3: 91.350–93.74; and Q4: >93.74 fl; for women, Q1: <87.58; Q2: 87.58–89.92; Q3: 89.93–92.15; and Q4: >92.15 fl. Values were analyzed after log transformation.

Table 2 | Results from adjusted multiple regression analyses

| Visceral fat area index | IMAT index | Total SMI | NAM index | LAM index | Total SMD |
|------------------------|------------|-----------|-----------|-----------|-----------|
| β                      | P-value    | β         | P-value   | β         | P-value   | β         | P-value   | β         | P-value   |
| MCV, adjusted model 1  | −0.160     | <0.0001   | −0.069    | 0.0338    | 0.103     | <0.0001   | 0.101     | <0.0001   | 0.054     | 0.1216    | 0.133     | <0.0001   |
| MCV, adjusted model 2  | −0.176     | <0.0001   | −0.077    | 0.0233    | 0.100     | 0.0001    | 0.115     | <0.0001   | −0.076    | 0.0381    | 0.152     | <0.0001   |
| MCV, adjusted model 3  | −0.112     | 0.0005    | −0.059    | 0.0883    | 0.055     | 0.0279    | 0.064     | 0.0130    | −0.043    | 0.2376    | 0.103     | 0.0009    |
| MCV, adjusted model 4  | −0.107     | 0.0007    | −0.058    | 0.0910    | 0.053     | 0.0341    | 0.061     | 0.0166    | −0.042    | 0.2566    | 0.099     | 0.0012    |

Model 1: adjusted for age and sex. Model 2: adjusted for model 1 covariates plus smoking status, drinking status and exercise status. Model 3: adjusted for model 2 covariates plus the prevalence of hypertension, dyslipidemia, diabetes mellitus, albumin, estimated glomerular filtration rate and C-reactive protein levels. Model 4: adjusted for model 3 covariates plus hemoglobin level, IMAT, intermuscular adipose tissue; LAM, low-attenuation muscle; MCV, mean corpuscular volume; NAM, normal-attenuation muscle; SMD, skeletal muscle density; SMI, skeletal muscle index.

Obesity and sarcopenic obesity are shown in Table 3. In model 4, MCV as a continuous variable and the highest MCV quartile were independently associated with the prevalence of sarcopenia or visceral obesity. Indeed, MCV as a continuous variable (OR 0.94, 95% CI 0.88–1.01; P = 0.0758) and highest MCV quartile (OR 0.54, 95% CI 0.29–1.01; P = 0.0539) tended to be independently associated with the prevalence of sarcopenic obesity, although it did not reach statistical significance.
In model 3, RBC count, hemoglobin, hematocrit or mean corpuscular hemoglobin levels were independently associated with the prevalence of sarcopenia, whereas mean corpuscular hemoglobin concentration levels were not. In the same model, RBC count, hemoglobin, hematocrit or mean corpuscular hemoglobin concentration levels were independently associated with the prevalence of visceral obesity, whereas mean corpuscular hemoglobin levels were not. In the same model, RBC count, hemoglobin or hematocrit levels were independently associated with the prevalence of sarcopenic obesity, whereas mean corpuscular hemoglobin or mean corpuscular hemoglobin concentration levels were not.

After adjustment for age, sex, smoking status, drinking status, exercise status, hypertension, dyslipidemia, albumin, estimated glomerular filtration rate, CRP and hemoglobin levels, MCV as a continuous variable was independently associated with the prevalence of sarcopenia (OR 0.74, 95% CI 0.68–0.84, P = 0.0003) or visceral obesity (OR 0.89, 95% CI 0.80–0.98; P = 0.0176) in subjects with normal glucose levels. In the same model, MCV was not associated with the prevalence of sarcopenia, visceral obesity, or sarcopenic obesity in subjects with prediabetes. In the same model, MCV was independently associated with the prevalence of sarcopenia (OR 0.37; 95% CI, 0.13–0.69; P = 0.0003) or sarcopenic obesity (OR 0.68, 95% CI 0.46–0.93; P = 0.0132) in participants with diabetes.

**DISCUSSION**

The present study has three principal survey results. First, even after full adjustment, MCV was related to the VFA index. Second, MCV was related to total SMI, NAM index and total SMD. In other words, MCV was related to both muscle quality and quantity. Third, MCV was related to the prevalence of sarcopenia or visceral obesity. Taken together, contrary to our prior hypothesis, we observed that a lower MCV was related to unfavorable body composition, leading to metabolic abnormalities in the participants without anemia and with normal MCV levels.

**Table 3** | Adjusted odds ratios and 95% confidence intervals for the prevalence of sarcopenia, visceral obesity and sarcopenic obesity

| MCV quartiles | Sarcopenia | | Visceral obesity | | Sarcopenic obesity | |
| | OR (95% CI) | P-value | OR (95% CI) | P-value | OR (95% CI) | P-value |
|---|---|---|---|---|---|---|
| **MCV, per 1.0 fl increment** | | | | | | |
| Model 1 | 0.89 (0.85–0.94) | <0.0001 | 0.89 (0.84–0.94) | <0.0001 | 0.90 (0.85–0.95) | 0.0002 |
| Model 2 | 0.90 (0.85–0.95) | <0.0001 | 0.88 (0.83–0.93) | <0.0001 | 0.90 (0.85–0.95) | 0.0002 |
| Model 3 | 0.93 (0.88–0.98) | 0.0086 | 0.91 (0.86–0.97) | 0.0022 | 0.94 (0.88–1.00) | 0.0659 |
| Model 4 | 0.93 (0.88–0.98) | 0.0097 | 0.91 (0.86–0.97) | 0.0046 | 0.94 (0.88–1.01) | 0.0758 |
| **MCV quartiles** | | | | | | |
| **Model 1** | | | | | | |
| Q1 | 1.00 | | 1.00 | | 1.00 | |
| Q2 | 0.67 (0.42–1.08) | 0.1007 | 0.56 (0.34–0.92) | 0.0207 | 0.46 (0.27–0.77) | 0.0033 |
| Q3 | 0.62 (0.38–0.99) | 0.0460 | 0.43 (0.26–0.71) | 0.0009 | 0.54 (0.32–0.90) | 0.0177 |
| Q4 | 0.34 (0.20–0.56) | <0.0001 | 0.37 (0.22–0.62) | 0.0001 | 0.37 (0.21–0.63) | 0.0003 |
| **Model 2** | | | | | | |
| Q1 | 1.00 | | 1.00 | | 1.00 | |
| Q2 | 0.69 (0.42–1.11) | 0.1279 | 0.55 (0.34–0.91) | 0.0186 | 0.46 (0.27–0.78) | 0.0037 |
| Q3 | 0.65 (0.40–1.06) | 0.0841 | 0.43 (0.26–0.72) | 0.0013 | 0.54 (0.32–0.92) | 0.0244 |
| Q4 | 0.36 (0.21–0.60) | <0.0001 | 0.35 (0.20–0.60) | 0.0001 | 0.37 (0.20–0.64) | 0.0004 |
| **Model 3** | | | | | | |
| Q1 | 1.00 | | 1.00 | | 1.00 | |
| Q2 | 0.76 (0.45–1.26) | 0.2861 | 0.63 (0.37–1.06) | 0.0836 | 0.51 (0.28–0.91) | 0.0227 |
| Q3 | 0.87 (0.52–1.47) | 0.6119 | 0.55 (0.31–0.95) | 0.0330 | 0.80 (0.45–1.43) | 0.4506 |
| Q4 | 0.48 (0.28–0.84) | 0.0095 | 0.49 (0.28–0.87) | 0.0153 | 0.55 (0.29–1.01) | 0.0558 |
| **Model 4** | | | | | | |
| Q1 | 1.00 | | 1.00 | | 1.00 | |
| Q2 | 0.76 (0.46–1.27) | 0.3046 | 0.65 (0.38–1.11) | 0.1124 | 0.51 (0.28–0.92) | 0.0252 |
| Q3 | 0.92 (0.54–1.54) | 0.7438 | 0.62 (0.35–1.09) | 0.0997 | 0.86 (0.48–1.55) | 0.6259 |
| Q4 | 0.48 (0.27–0.83) | 0.0089 | 0.49 (0.27–0.88) | 0.0170 | 0.54 (0.29–1.01) | 0.0539 |

For men, quartile (Q1): <88.62; Q2: 88.62–91.349; Q3: 91.350–93.74; and Q4: >93.74 fl; for women, Q1: <87.58; Q2: 87.58–89.92; Q3: 89.93–92.15; and Q4: >92.15 fl. Model 1: adjusted for age and sex. Model 2: adjusted for model 1 covariates plus smoking status, drinking status and exercise status. Model 3: adjusted for model 2 covariates plus the prevalence of hypertension, dyslipidemia, diabetes mellitus, albumin, estimated glomerular filtration rate and C-reactive protein levels. Model 4: adjusted for model 3 covariates plus hematocrit level. CI, confidence interval; MCV, mean corpuscular volume; OR, odds ratio.
The present study provides some support to previous investigations. First, Cazzola et al. showed that athletes undergoing regular and adequate training had higher MCV than sedentary individuals. Second, several studies in individuals with chronic kidney disease, heart failure or in a non-anemic healthy population showed that higher MCV levels were associated with mortality or heart failure, which was the main outcome of the studies. However, these studies showed that a higher MCV was associated with lower BMI, glycated hemoglobin, cholesterol, triglyceride or uric acid levels, and a lower prevalence of diabetes mellitus, dyslipidemia and hypertension. Third, Sun et al. showed that a low MCV predicts a high risk of in-stent restenosis. Taken together, it seems plausible that a lower MCV is associated with lower muscle quality, lower muscle quantity, sarcopenia or visceral obesity in individuals without anemia and normal MCV levels.

There are several potential mechanisms that might explain the present findings. First, obesity is associated with an increase in inflammation, which is related to an increase in oxidative stress. Indeed, oxidative stress is associated with RBC shrinkage, and inflammation itself is a leading cause of microcytosis. In addition, sarcopenia is associated with reactive oxygen and nitrogen species. The disproportion between reactive oxygen and nitrogen species production and these anti-oxidant defenses causes oxidative stress. Sportsmen undergoing sufficient training had made better anti-oxidant conditions, along with a more fluid membrane status of RBCs. Second, MCV might be a biomarker of cell dehydration, shrinkage or swelling. The crystal osmotic pressure regulates erythrocyte volume, and increased crystal osmotic pressure might induce erythrocyte shrinkage and lower MCV. Arginine vasopressin secretion increases with increasing crystal osmotic pressure, which is associated with lower MCV levels. Higher fasting arginine vasopressin levels are related to diabetes and obesity, because of the effectiveness of arginine vasopressin on adrenocorticotropic hormone and cortisol release. In contrast, cell swelling causes anabolic effects, and the stimulation of glycogen synthesis, and decreases proteolysis. A study reported that the decrement of crystal osmotic pressure promoted lipolysis and counteracted proteolysis.

The clinical relevance regards the diagnostic utility of MCV, as a provisional new marker of lower muscle quality, lower muscle quantity, sarcopenia and visceral obesity, that can be measured easily in the clinical laboratory and applied in medical practice. For the individuals who are generally considered healthy, the interesting concept of a role for MCV in unfavorable body composition holds great promise for the development of new preventive measures. However, the cross-sectional nature of the present study does not permit determination of causality. Indeed, it did not show whether MCV was a surrogate or predictable marker for clinical outcome. Therefore, large prospective studies are required to better assess the relationship between MCV levels and clinical outcome.

The present study had four limitations. First, the research participants were only Japanese. Racial characteristics are a significant factor of variation in body composition, and Western individuals have more muscle mass and less body adipose tissue compared with Asian individuals with the same BMI. Therefore, generalizations to other races must be carried out with care. Second, we did not rule out the possibility of bone marrow malfunction, and did not measure factors affecting RBC size, such as thyroid function, iron, folic acid and vitamin B12 levels. Therefore, we excluded individuals with anemia or with abnormal MCV. Indeed, MCV was not related to white blood cell count, which was related to bone marrow function. Third, we did not propose a cut-off value of MCV for the prevalence of sarcopenia or visceral obesity, because MCV is associated with age. Our result is also in line with previous findings; indeed, in our unadjusted model, there were no significant differences across the MCV quartiles in terms of body composition parameters. However, in the age-adjusted model, MCV was related to several body composition parameters. Finally, we discussed possible underlying mechanisms regarding the association of MCV and body composition parameters. However, there are no data showing such mechanisms in the present study. Therefore, additional research is required to support the present findings.

In individuals without anemia and with normal MCV levels, a lower MCV was associated with unfavorable body composition, including lower muscle quality, lower muscle quantity, sarcopenia and visceral obesity.

DISCLOSURE
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