

Supplementary Files

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Supplementary Materials Overview

The Supplementary Materials provide additional details to support the cohort definition, feature selection, and subgroup analyses presented in the main manuscript.

Cohort definition: **Figure S1** presents the flowchart of participant selection for the external validation cohort, clarifying inclusion and exclusion procedures.

Feature selection and multicollinearity assessment: **Table S1** reports correlation analyses between MAFLD and clinical/body composition variables. **Table S2** summarizes variance inflation factor (VIF) values for all candidate variables, and **Table S3** provides the VIF values for variables retained in the final model after multicollinearity control.

Model interpretability: **Table S4** lists the mean absolute SHAP values for all candidate features, providing complementary evidence for feature importance.

Subgroup analyses: Baseline characteristics and multivariable logistic regression results are provided for key subgroups, including sex (**Tables S5–S6**), age group (<40 vs ≥ 40 years; **Tables S7–S8**), and BMI category (**Tables S9–S10**), to illustrate potential heterogeneity in associations across populations.

Code and Data Availability

The code used for data preprocessing, model training, evaluation, and interpretation is available from the following GitHub repository:

<https://github.com/hyaxuan23-lab/ML-for-Non-Invasive-MAFLD-Identification>

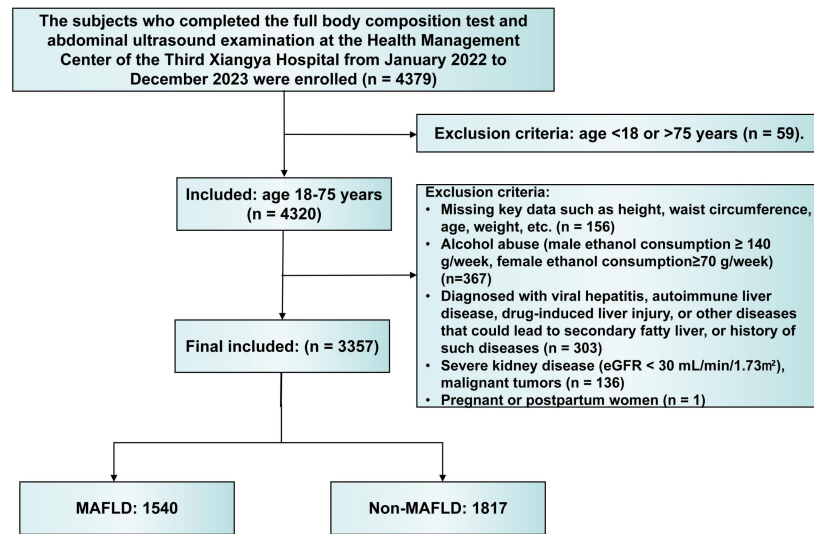


Fig. S1 Flowchart of Participant Selection for the External Validation Cohort

Participants were enrolled from the Health Management Center of the Third Xiangya Hospital between January 2022 and December 2023. After excluding individuals outside the age range of 18–75 years and those with missing key data, alcohol abuse, liver-related comorbidities, severe kidney disease, malignancies, or pregnancy, a total of 3,357 participants were included. Among them, 1,540 were diagnosed with MAFLD and 1,817 were classified as non-MAFLD.

Table S1. Correlation Analysis Between MAFLD and Clinical or Body Composition Variables

Variables	Correlation coefficient(r)	p-value
VFR, level	0.743	<0.001
WC, cm	0.717	<0.001
Weight, kg	0.678	<0.001
BMI	0.669	<0.001
ECW%	0.609	<0.001
BMR,kcal/day	0.594	<0.001
Muscle, kg	0.593	<0.001
LeanM, kg	0.593	<0.001
Bone, kg	0.577	<0.001
Water ,kg	0.553	<0.001
Sex	-0.485	<0.001
FatM, kg	0.483	<0.001
HDL,mmol/L	-0.408	<0.001
DBP,mmHg	0.359	<0.001
Height, cm	0.332	<0.001
TG, mmol/L	0.325	<0.001
ALT, U/L	0.320	<0.001
SBP,mmHg	0.309	<0.001
Smoking	0.278	<0.001
Water%	-0.236	<0.001
FBG, mmol/L	0.229	<0.001
TC, mmol/L	0.156	<0.001
Age	0.137	<0.001
Alcohol	0.132	<0.001
Hypertension	0.124	<0.001
ALB, g/L	0.090	<0.001
Diabetes	0.085	<0.001
TP, g/L	0.061	<0.001
TBIL, μ mol/L	0.023	<0.001
LDL, mmol/L	0.019	0.004
Fat%	0.009	0.172
GLOB, g/L	0.001	0.840

This table presents the Pearson correlation coefficients (r) between MAFLD status and various clinical and body composition indicators. Variables such as VFR, WC, and weight showed strong positive correlations with MAFLD, while sex and HDL were negatively correlated. All p-values < 0.05 were considered statistically significant. VFR (r = 0.743) and WC (r = 0.717) exhibited the strongest associations. Variables such as GLOB and Fat% (from blood test) showed no significant correlation (p > 0.05).

BMI, body mass index; ALT, alanine aminotransferase; TP, total protein; ALB, albumin; GLOB, globulin; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride;

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FatM, fat mass; LeanM, lean mass; ECW%, extracellular water percentage; VFR, visceral fat rating; BMR, basal metabolic rate; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; Water, total body water ; Water%, body water percentage; Muscle, muscle mass; Bone, estimated bone mass.

Table S2. Variance Inflation Factor (VIF) Values for All Candidate Variables

Variable	VIF
WC	9.240
BMI	20.797
FatM	38.995
LeanM	1542.750
Muscle	1495.421
Bone	40.174
Water	11.537
Water%	9.854
ECW%	6.932
VFR	40.128
BMR	517.900
Sex	18.863
Age	7.551

This table shows the VIF values for all candidate variables considered in the initial feature selection process. Variables with $VIF > 10$ were considered to have high multicollinearity and were excluded from the final model.

VFR, visceral fat rating; WC, waist circumference; BMI, body mass index; ECW%, extracellular water percentage; Water%, body water percentage; FatM, fat mass; BMR, basal metabolic rate; LeanM, lean mass; Water, total body water; Muscle, muscle mass; Bone, estimated bone mass.

Table S3. VIF Values of Variables Included in the Final Predictive Model

Variable	VIF
WC	7.147
Water	5.174
ECW%	6.200
VFR	9.380
Sex	2.754
Age	1.565

This table lists the VIF values for the variables retained in the final model. All values were below the predefined threshold ($VIF < 10$), indicating acceptable multicollinearity.

Table S4. Mean Absolute SHAP Values for All Candidate Features

Feature	SHAP_MeanAbs
VFR	2.529
WC	0.880
BMI	0.441
ECW%	0.080
Water%	0.069
Age	0.061
FatM	0.056
Muscle	0.024
BMR	0.023
LeanM	0.022
Water	0.020
Bone	0.007
Sex	0.00

This table displays the mean absolute SHAP values for each candidate variable, reflecting their relative importance in the prediction of MAFLD using the XGBoost model. VFR, WC, and BMI showed the highest contributions to model output. Features with minimal SHAP values (e.g., sex and bone mass) were considered to have negligible influence.

VFR, visceral fat rating; WC, waist circumference; BMI, body mass index; ECW%, extracellular water percentage; Water%, body water percentage; FatM, fat mass; BMR, basal metabolic rate; LeanM, lean mass; Water, total body water; Muscle, muscle mass; Bone, estimated bone mass.

Table S5. Baseline Characteristics of the Study Population by Sex

Variables	Total population (n=23348)	MALE (n=8786)	FEMALE(n=14562)	P-value
Age,years	42.00 (34.00-51.00)	42.00 (34.00-51.00)	43.00 (34.00-51.00)	0.338
Height,cm	165.00 (159.00-170.60)	169.00 (165.00-173.20)	157.70 (154.10-161.50)	<0.001
Weight,kg	66.15 (57.10-75.35)	72.22 (65.45-79.55)	55.65 (50.80-61.15)	<0.001
SBP,mmHg	121.00 (111.00-131.00)	124.00 (115.00-133.00)	114.00 (105.00-126.00)	<0.001
DBP,mmHg	74.00 (67.00-83.00)	77.00 (70.00-85.00)	69.00 (63.00-77.00)	<0.001
WC,cm	84.00 (76.00-92.00)	89.00 (83.00-95.00)	76.00 (70.00-82.00)	<0.001
BMI,kg/m ²	24.27 (21.94-26.76)	25.31 (23.25-27.53)	22.33 (20.44-24.64)	<0.001
ALT,U/L	23.00 (15.00-35.00)	28.00 (20.00-42.00)	15.00 (12.00-22.00)	<0.001
TP,g/L	73.50 (70.80-76.40)	73.60 (70.90-76.40)	73.45 (70.70-76.30)	0.007
ALB,g/L	46.90 (45.00-48.70)	47.40 (45.60-49.20)	45.90 (44.20-47.70)	<0.001
GLOB,g/L	26.60 (24.30-29.00)	26.10 (23.80-28.40)	27.50 (25.20-29.80)	<0.001
FBG,mmol/L	5.29 (4.96-5.72)	5.37 (5.02-5.83)	5.18 (4.88-5.53)	<0.001
TC,mmol/L	4.95 (4.38-5.59)	5.01 (4.45-5.64)	4.85 (4.28-5.51)	<0.001
TG,mmol/L	1.47 (0.97-2.29)	1.79 (1.21-2.73)	1.07 (0.76-1.56)	<0.001
HDL-C,mmol/L	1.24 (1.07-1.44)	1.15 (1.02-1.30)	1.42 (1.25-1.62)	<0.001
LDL-C,mmol/L	2.83 (2.32-3.36)	2.85 (2.33-3.38)	2.78 (2.32-3.32)	0.923
FatM, kg	16.70 (13.40-20.70)	16.55 (13.15-20.55)	16.95 (13.75-20.95)	<0.001
LeanM, kg	50.75 (39.95-57.10)	55.55 (51.75-59.70)	38.65 (36.45-40.85)	<0.001
Muscle, kg	48.10 (37.60-54.15)	52.65 (49.05-56.60)	36.45 (34.40-38.45)	<0.001
Bone, kg	2.70 (2.30-2.95)	2.90 (2.70-3.10)	2.20 (2.05-2.40)	<0.001
Water, kg	34.15 (28.60-38.70)	37.50 (34.50-40.79)	27.55 (25.70-29.70)	<0.001
Water%	50.80 (48.10-53.90)	52.00 (48.90-55.10)	49.40 (47.20-51.70)	<0.001
ECW%	14.20 (12.05-15.55)	15.20 (14.30-16.15)	11.50 (10.65-12.50)	<0.001
VFR,level	9.00 (5.00-12.00)	11.00 (9.00-14.00)	5.00 (3.00-7.00)	<0.001
BMR, kcal/L	1406.00 (1180.00-1596.00)	1546.00 (1425.00-1680.00)	1142.00 (1073.00-1218.00)	<0.001
Hypertension,n(%)	1495 (6.4%)	634(7.22%)	734(5.04%)	<0.001
Diabetes,n(%)	579 (2.48%)	278(3.16%)	199(1.37%)	<0.001
Smoking,n(%)	8582 (36.76%)	4911(55.9%)	732(5.03%)	<0.001
Alcohol,n(%)	5412 (23.18%)	2841(32.34%)	1165(8.00%)	<0.001
MAFLD,n(%)	9479(40.60%)	5191(59.08%)	1452(9.97%)	<0.001

This table summarizes the baseline demographic, clinical, and body composition characteristics of the total study population and stratifies the results by sex. Continuous variables are presented as medians with interquartile ranges (IQRs), and categorical variables are shown as counts and percentages. P-values are derived from the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables. Significant sex-based differences were observed in most variables, including visceral fat area (VFR), BMI, body water composition, metabolic markers, and MAFLD prevalence (male: 59.08%, female: 9.97%).

BMI, body mass index; ALT, alanine aminotransferase; TP, total protein; ALB, albumin; GLOB, globulin; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FatM, fat mass; LeanM, lean mass; ECW%, extracellular water percentage; VFR, visceral fat rating; BMR, basal metabolic rate; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; Water, total body water ; Water%, body water percentage; Muscle, muscle mass; Bone,estimated bone mass.

Table S6. Sex-Stratified Logistic Regression Analysis of Body Composition Indicators Associated with MAFLD

Sex	Variables	Model1		Model2	
		OR (95%CI)	P-value	OR (95%CI)	P-value
Male	FatM	1.511(1.490-1.532)	<0.001	1.076(1.052-1.099)	<0.001
	LeanM	1.187(1.178-1.195)	<0.001	0.934(0.924-0.945)	<0.001
	Muscle	1.198(1.188-1.207)	<0.001	0.931(0.920-0.942)	<0.001
	Bone	30.611(26.404-35.489)	<0.001	0.259(0.206-0.325)	<0.001
	Water	1.192(1.182-1.203)	<0.001	0.926(0.914-0.939)	<0.001
	Water%	0.783(0.776-0.791)	<0.001	0.928(0.916-0.940)	<0.001
	ECW%	2.742(2.641-2.847)	<0.001	0.962(0.921-1.004)	0.213
	VFR	2.248(2.188-2.308)	<0.001	1.564(1.510-1.620)	<0.001
	BMR	1.005(1.005-1.005)	<0.001	0.997(0.997-0.998)	<0.001
Female	FatM	1.572(1.531-1.614)	<0.001	1.053(1.001-1.107)	0.045
	LeanM	1.342(1.313-1.373)	<0.001	0.985(0.948-1.024)	0.452
	Muscle	1.380(1.347-1.413)	<0.001	0.986(0.945-1.028)	0.500
	Bone	29.937(23.120-38.762)	<0.001	0.689(0.438-1.085)	0.108
	Water	1.621(1.575-1.668)	<0.001	0.925(0.880-0.973)	0.002
	Water%	0.558(0.539-0.577)	<0.001	0.874(0.833-0.917)	<0.001
	ECW%	3.504 (3.259-3.766)	<0.001	1.051(0.990-1.116)	0.106
	VFR	3.335 (3.095-3.593)	<0.001	1.787(1.627-1.964)	<0.001
	BMR	1.011 (1.010-1.012)	<0.001	0.999(0.997-1.000)	0.018

This table presents the results of sex-stratified logistic regression analyses examining the association between body composition variables and the presence of MAFLD in males and females. Model 1 includes all candidate variables, while Model 2 adjusts for potential multicollinearity and confounders. ORs with 95% CIs and corresponding p-values are reported. VFR remained a significant predictor in both sexes across models, whereas the influence of other variables, such as bone mass, lean mass, and ECW%, varied by sex and model adjustment. FatM, fat mass; LeanM, lean mass; ECW%, extracellular water percentage; VFR, visceral fat rating; BMR, basal metabolic rate; Water, total body water ; Water%, body water percentage; Muscle, muscle mass; Bone, estimated bone mass.

Table S7. Baseline Characteristics of the Study Population Stratified by Age Group (<40 and ≥40 Years)

Variables	Total population (n=23348)	<40 years (n=13367)	≥40 years (n=9981)	P-value
Male,n(%)	14562(62.37%)	8487(63.49%)	6075(61.53%)	0.002
Age,years	42.00 (34.00-51.00)	33.00 (29.00-36.00)	49.00 (44.00-55.00)	<0.001
Height,cm	165.00 (159.00-170.60)	167.00 (161.00-172.50)	163.70 (157.60-169.10)	<0.001
Weight,kg	66.15 (57.10-75.35)	67.05 (56.15-77.60)	65.65 (57.75-74.15)	<0.001
SBP,mmHg	121.00 (111.00-131.00)	117.00 (109.00-127.00)	123.00 (113.00-135.00)	<0.001
DBP,mmHg	74.00 (67.00-83.00)	72.00 (65.00-79.00)	76.00 (69.00-85.00)	<0.001
WC,cm	84.00 (76.00-92.00)	82.00 (73.00-91.00)	86.00 (79.00-92.00)	<0.001
BMI,kg/m2	24.27 (21.94-26.76)	23.84 (21.13-26.81)	24.52 (22.46-26.72)	<0.001
ALT,U/L	23.00 (15.00-35.00)	23.00 (14.00-40.00)	22.00 (16.00-32.00)	<0.001
TP,g/L	73.50 (70.80-76.40)	74.30 (71.70-77.10)	72.90 (70.20-75.80)	<0.001
ALB,g/L	46.90 (45.00-48.70)	47.80 (46.00-49.60)	46.10 (44.40-47.90)	<0.001
GLOB,g/L	26.60 (24.30-29.00)	26.50 (24.20-28.80)	26.70 (24.40-29.20)	<0.001
FBG,mmol/L	5.29 (4.96-5.72)	5.15 (4.86-5.48)	5.43 (5.06-5.91)	<0.001
TC,mmol/L	4.95 (4.38-5.59)	4.77 (4.23-5.38)	5.10 (4.50-5.74)	<0.001
TG,mmol/L	1.47 (0.97-2.29)	1.35 (0.86-2.25)	1.55 (1.06-2.31)	<0.001
HDL-C,mmol/L	1.24 (1.07-1.44)	1.22 (1.06-1.42)	1.25 (1.09-1.45)	<0.001
LDL-C,mmol/L	2.83 (2.32-3.36)	2.71 (2.25-3.21)	2.92 (2.39-3.46)	<0.001
FatM	16.70 (13.40-20.70)	16.10 (12.65-20.70)	17.10 (13.95-20.70)	<0.001
LeanM	50.75 (39.95-57.10)	52.30 (40.30-58.80)	49.85 (39.75-55.90)	<0.001
Muscle	48.10 (37.60-54.15)	49.55 (37.95-55.75)	47.20 (37.45-53.00)	<0.001
Bone	2.70 (2.30-2.95)	2.75 (2.35-3.05)	2.65 (2.30-2.90)	<0.001
Water	34.15 (28.60-38.70)	34.80 (28.40-39.60)	33.70 (28.70-38.10)	<0.001
Water%	50.80 (48.10-53.90)	51.00 (48.20-54.10)	50.70 (48.00-53.70)	<0.001
ECW%	14.20 (12.05-15.55)	14.05 (11.55-15.55)	14.30 (12.35-15.55)	<0.001
VFR	9.00 (5.00-12.00)	8.00 (4.00-11.00)	10.00 (7.00-13.00)	<0.001
BMR	1406.00 (1180.00-1596.00)	1470.00 (1206.00-1666.00)	1366.00 (1163.00-1545.00)	<0.001
Hypertension,n(%)	1495 (6.4%)	166(1.24%)	1024(10.26%)	<0.001
Diabetes,n(%)	579 (2.48%)	51(0.38%)	404(4.05%)	<0.001
Smoking,n(%)	8582 (36.76%)	5071(37.94%)	3580(35.87%)	0.001
Alcohol,n(%)	5412 (23.18%)	3912(29.27%)	1860(18.64%)	<0.001
MAFLD,n(%)	9479(40.60%)	4465(33.40%)	4588(45.97%)	<0.001

This table presents the baseline demographic, clinical, and body composition characteristics of the total study population, stratified by age group. Continuous variables are presented as medians with interquartile ranges (IQRs), and categorical variables are expressed as counts and percentages. Comparisons between groups were performed using the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables.

BMI, body mass index; ALT, alanine aminotransferase; TP, total protein; ALB, albumin; GLOB, globulin; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FatM, fat mass; LeanM, lean mass; ECW%, extracellular water percentage; VFR, visceral fat rating; BMR, basal metabolic rate; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; Water, total body water ; Water%, body water percentage; Muscle, muscle mass; Bone,estimated bone mass.

Table S8. Age-Stratified Logistic Regression Analysis of Body Composition Indicators Associated with MAFLD

Age	Variables	Model1		Model2	
		OR (95%CI)	P-value	OR (95%CI)	P-value
≥40	FatM	1.192(1.183-1.202)	<0.001	1.132(1.103-1.161)	<0.001
	LeanM	1.200(1.193-1.207)	<0.001	0.965(0.952-0.979)	<0.001
	Muscle	1.209(1.202-1.217)	<0.001	0.964(0.949-0.979)	<0.001
	Bone	74.243(64.001-86.123)	<0.001	0.599(0.462-0.776)	<0.001
	Water	1.316(1.303-1.328)	<0.001	0.951(0.935-0.968)	<0.001
	Water%	0.929(0.922-0.937)	<0.001	0.905(0.891-0.92)	<0.001
	ECW%	2.795(2.7-2.892)	<0.001	0.988(0.947-1.031)	0.583
	VFR	2.082(2.032-2.134)	<0.001	1.331(1.271-1.392)	<0.001
	BMR	1.008(1.008-1.008)	<0.001	0.999(0.998-0.999)	<0.001
<40	FatM	1.347(1.331-1.364)	<0.001	1.094(1.057-1.132)	<0.001
	LeanM	1.235(1.225-1.246)	<0.001	0.954(0.936-0.972)	<0.001
	Muscle	1.246(1.235-1.258)	<0.001	0.951(0.932-0.971)	<0.001
	Bone	152.313(123.597-187.701)	<0.001	0.422(0.292-0.609)	<0.001
	Water	1.323(1.308-1.338)	<0.001	0.922(0.902-0.943)	<0.001
	Water%	0.833(0.823-0.842)	<0.001	0.906(0.886-0.927)	<0.001
	ECW%	2.914(2.785-3.049)	<0.001	0.883(0.809-0.964)	0.006
	VFR	3.133(2.968-3.308)	<0.001	2.137(1.939-2.356)	<0.001
	BMR	1.008(1.008-1.008)	<0.001	0.998(0.997-0.999)	<0.001

This table shows the results of logistic regression analyses assessing the association between body composition indicators and MAFLD, stratified by age group (<40 years and ≥40 years). Model 1 includes all candidate variables, while Model 2 adjusts for potential confounding and multicollinearity. ORs with 95% CIs and p-values are reported. VFR remained a strong and consistent predictor in both age groups. Some variables, such as bone mass and muscle mass, showed substantial attenuation or reversal of effect direction after adjustment in Model 2. FatM, fat mass; LeanM, lean mass; ECW%, extracellular water percentage; VFR, visceral fat rating; BMR, basal metabolic rate; Water, total body water ; Water%, body water percentage; Muscle, muscle mass; Bone, estimated bone mass.

Table S9. Baseline Characteristics of the Study Population Stratified by BMI Category

Variables	Total population (n=23348)	BMI<24 (N=10960)	BMI:24-28 (N=8680)	BMI>28 (N=3708)	P-value
Male,n(%)	14562(62.37%)	4866(44.40%)	6657(76.69%)	3039(81.96%)	
Age,years	42.00 (34.00-51.00)	41.00 (33.00 - 50.00)	44.00 (36.00 - 52.00)	41.00 (33.00 - 50.00)	<0.001
Height,cm	165.00 (159.00-170.60)	162.70 (157.50 - 168.90)	166.65 (160.57 - 171.50)	168.00 (162.30 - 172.50)	<0.001
Weight,kg	66.15 (57.10-75.35)	56.85 (51.65 - 62.90)	71.55 (66.00 - 76.50)	84.20 (78.15 - 91.10)	<0.001
SBP,mmHg	121.00 (111.00-131.00)	115.00 (106.00 - 126.00)	124.00 (114.00 - 133.00)	129.00 (120.00 - 138.00)	<0.001
DBP,mmHg	74.00 (67.00-83.00)	70.00 (64.00 - 78.00)	77.00 (70.00 - 84.00)	81.00 (74.00 - 88.00)	<0.001
WC,cm	84.00 (76.00-92.00)	76.00 (71.00 - 81.00)	89.00 (85.00 - 93.00)	98.00 (94.00 - 103.00)	<0.001
ALT,U/L	23.00 (15.00-35.00)	17.00 (12.00 - 24.25)	26.00 (19.00 - 39.00)	37.00 (25.00 - 56.00)	<0.001
TP,g/L	73.50 (70.80-76.40)	73.30 (70.60 - 76.20)	73.60 (70.90 - 76.30)	74.00 (71.40 - 76.90)	<0.001
ALB,g/L	46.90 (45.00-48.70)	46.70 (44.80 - 48.60)	47.00 (45.10 - 48.80)	47.20 (45.20 - 49.00)	<0.001
GLOB,g/L	26.60 (24.30-29.00)	26.60 (24.20 - 29.00)	26.50 (24.30 - 29.00)	27.00 (24.60 - 29.30)	<0.001
FBG,mmol/L	5.29 (4.96-5.72)	5.15 (4.86 - 5.49)	5.40 (5.06 - 5.85)	5.54 (5.13 - 6.13)	<0.001
TC,mmol/L	4.95 (4.38-5.59)	4.81 (4.26 - 5.43)	5.07 (4.49 - 5.71)	5.10 (4.53 - 5.76)	<0.001
TG,mmol/L	1.47 (0.97-2.29)	1.11 (0.79 - 1.63)	1.76 (1.21 - 2.66)	2.15 (1.51 - 3.31)	<0.001
HDL-C,mmol/L	1.24 (1.07-1.44)	1.36 (1.18 - 1.57)	1.17 (1.04 - 1.33)	1.09 (0.97 - 1.23)	<0.001
LDL-C,mmol/L	2.83 (2.32-3.36)	2.77 (2.31 - 3.28)	2.91 (2.36 - 3.44)	2.84 (2.27 - 3.39)	<0.001
FatM	16.70 (13.40-20.70)	13.55 (11.05 - 16.00)	18.40 (16.00 - 21.05)	25.45 (22.35 - 29.60)	<0.001
LeanM	50.75 (39.95-57.10)	41.50 (37.45 - 50.55)	54.45 (48.10 - 58.30)	60.10 (54.90 - 64.55)	<0.001
Muscle	48.10 (37.60-54.15)	39.10 (35.35 - 47.90)	51.60 (45.55 - 55.30)	57.00 (52.05 - 61.20)	<0.001
Bone	2.70 (2.30-2.95)	2.40 (2.10 - 2.65)	2.85 (2.60 - 3.00)	3.10 (2.90 - 3.35)	<0.001
Water	34.15 (28.60-38.70)	29.02 (26.25 - 34.00)	36.55 (32.65 - 39.60)	40.90 (36.90 - 44.40)	<0.001
Water%	50.80 (48.10-53.90)	51.90 (49.50 - 55.20)	50.50 (47.80 - 53.40)	47.90 (45.10 - 50.80)	<0.001
ECW%	14.20 (12.05-15.55)	12.10 (10.90 - 13.95)	15.00 (13.90 - 15.80)	16.50 (15.50 - 17.40)	<0.001
VFR	9.00 (5.00-12.00)	5.00 (3.00 - 8.00)	11.00 (9.00 - 13.00)	15.00 (13.00 - 16.00)	<0.001
BMR	1406.00 (1180.00-1596.00)	1209.00 (1098.00 - 1393.25)	1511.00 (1346.00 - 1630.00)	1703.00 (1541.00 - 1857.00)	<0.001
Hypertension,n(%)	1495 (6.4%)	375(3.26%)	728(8.39%)	410(11.06%)	<0.001

Diabetes,n(%)	580 (2.5%)	189(1.72%)	270(3.11%)	121(3.26%)	<0.001
Smoking,n(%)	8582 (36.8%)	2891(26.38%)	3764(43.36%)	1927(51.97%)	<0.001
Alcohol,n(%)	5413 (23.2%)	1950(17.79%)	2413(27.80%)	1050(28.32%)	<0.001
MAFLD,n(%)	9479(40.60%)	783(7.14%)	5222(60.16%)	3474(93.69%)	<0.001

This table summarizes the demographic, clinical, and body composition characteristics of the study population stratified by BMI categories: <24 kg/m² (normal weight), 24–28 kg/m² (overweight), and >28 kg/m² (obesity). Continuous variables are reported as medians with interquartile ranges, and categorical variables are expressed as counts and percentages. Statistical comparisons were conducted using the Kruskal–Wallis test for continuous variables and the chi-square test for categorical variables. Significant differences were observed across BMI groups in nearly all variables, including body fat composition, metabolic parameters, and MAFLD prevalence (7.14% in BMI <24 kg/m² vs. 93.69% in BMI >28 kg/m²).

BMI, body mass index; ALT, alanine aminotransferase; TP, total protein; ALB, albumin; GLOB, globulin; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FatM, fat mass; LeanM, lean mass; ECW%, extracellular water percentage; VFR, visceral fat rating; BMR, basal metabolic rate; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; Water, total body water ; Water%, body water percentage; Muscle, muscle mass; Bone,estimated bone mass.

Table S10. BMI-Stratified Logistic Regression Analysis of Body Composition Indicators Associated with MAFLD

BMI	Variables	Model1		Model2	
		OR (95%CI)	P-value	OR (95%CI)	P-value
BMI < 24	FatM	1.093(1.071-1.115)	<0.001	1.130(1.082-1.181)	<0.001
	LeanM	1.156(1.143-1.169)	<0.001	0.880(0.860-0.901)	<0.001
	Muscle	1.166(1.152-1.179)	<0.001	0.874(0.853-0.896)	<0.001
	Bone	17.599(13.826-22.402)	<0.001	0.079(0.050-0.125)	<0.001
	Water	1.183(1.166-1.201)	<0.001	0.854(0.829-0.879)	<0.001
	Water%	0.957(0.941-0.974)	<0.001	0.910(0.888-0.934)	<0.001
	ECW%	1.996(1.893-2.105)	<0.001	1.345(1.278-1.367)	<0.001
	VFR	2.812(2.638-2.998)	<0.001	2.305(2.140-2.483)	<0.001
	BMR	1.005(1.004-1.005)	<0.001	0.995(0.994-0.996)	<0.001
BMI:24-28	FatM	0.964(0.953-0.975)	<0.001	1.070(1.043-1.097)	<0.001
	LeanM	1.146(1.138-1.154)	<0.001	0.949(0.936-0.963)	<0.001
	Muscle	1.153(1.145-1.161)	<0.001	0.947(0.933-0.96)	<0.001
	Bone	16.709(14.239-19.608)	<0.001	0.416(0.322-0.537)	<0.001
	Water	1.185(1.173-1.198)	<0.001	0.945(0.929-0.961)	<0.001
	Water%	1.016(1.005-1.027)	0.003	0.929(0.914-0.945)	<0.001
	ECW%	2.215(2.129-2.305)	<0.001	1.004(0.960-1.050)	0.853
	VFR	2.001(1.943-2.062)	<0.001	1.440(1.380-1.501)	<0.001
	BMR	1.005(1.004-1.005)	<0.001	0.998(0.998-0.998)	<0.001
BMI > 28	FatM	1.027(1.003-1.051)	0.024	1.019(0.969-1.072)	0.459
	LeanM	1.065(1.050-1.079)	<0.001	0.971(0.941-1.003)	0.074
	Muscle	1.068(1.053-1.082)	<0.001	0.970(0.938-1.003)	0.076
	Bone	3.878(2.780-5.41)	<0.001	0.570(0.333-0.977)	0.041
	Water	1.097(1.070-1.124)	<0.001	0.966(0.930-1.003)	0.072
	Water%	0.983(0.953-1.014)	0.267	0.969(0.930-1.010)	0.140
	ECW%	1.436(1.315-1.567)	<0.001	1.008(1.003-1.105)	0.005
	VFR	1.379(1.313-1.449)	<0.001	1.178(1.069-1.298)	0.001
	BMR	1.002(1.002-1.003)	<0.001	0.999(0.998-1.000)	0.021

This table presents the results of logistic regression analyses assessing the associations between body composition variables and MAFLD, stratified by BMI categories (<24 kg/m², 24–28 kg/m², and >28 kg/m²). Model 1 includes all candidate variables without adjustment, while Model 2 adjusts for potential confounding and multicollinearity. ORs with 95% CIs and p-values are reported. VFR remained a significant predictor across all BMI strata. In the BMI <24 and 24–28 groups, most body composition features showed significant associations with MAFLD risk, whereas in the BMI >28 group, only a subset remained significant after adjustment.

FatM, fat mass; LeanM, lean mass; ECW%, extracellular water percentage; VFR, visceral fat rating; BMR, basal metabolic rate; Water, total body water ; Water%, body water percentage; Muscle, muscle mass; Bone, estimated bone mass.