Supplementary Information

1 Supplementary Tables

Supplementary Table 1: Metabolite list. Metabolites (n=228) analysed by Nightingale Health (see methods) used for analysis, including full names and abbreviations used throughout the main text. VLDL – very low density lipoprotein, IDL – intermediate density lipoprotein, LDL – low density lipoprotein and HDL – high density lipoprotein.

Abbreviation	Full description
AcAce	Acetoacetate
Ace	Acetate
Ala	Alanine
Alb	Albumin
ApoA1	Apolipoprotein A-I
ApoB	Apolipoprotein B
ApoB/ApoA1	Ratio of apolipoprotein B to apolipoprotein A-I
bOHBut	3-hydroxybutyrate
Cit	Citrate
Crea	Creatinine
DHA	22:6, docosahexaenoic acid
DHA/FA	Ratio of 22:6, docosahexaenoic acids to total fatty acids
EstC	Esterified cholesterol
FAw3	Omega-3 fatty acids
FAw3/FA	Ratio of omega-3 fatty acids to total fatty acids
FAw6	Omega-6 fatty acids
FAw6/FA	Ratio of omega-6 fatty acids to total fatty acids
FreeC	Free cholesterol
Glc	Glucose
Gln	Glutamine
Glol	Glycerol
Gly	Glycine
Gp	Glycoprotein acetylation
HDL2-C	Total cholesterol in HDL2
HDL3-C	Total cholesterol in HDL3
HDL-C	Total cholesterol in HDL
HDL-D	Mean diameter for HDL particles
HDL-TG	Triglycerides in HDL
His	Histidine
IDL-C	Total cholesterol in IDL particles
IDL-C_%	Percentage of cholesterol in IDL particles
IDL-CE	Cholesterol esters in IDL particles

IDL-CE_%	Percentage of cholesterol esters in IDL particles
IDL-FC	Free cholesterol in IDL particles
IDL-FC_%	Percentage of free cholesterol in IDL particles
IDL-L	Total lipids in IDL particles
IDL-P	Concentration of IDL particles
IDL-PL	Phospholipids in IDL particles
IDL-PL_%	Percentage of phospholipids in IDL particles
IDL-TG	Triglycerides in IDL particles
IDL-TG_%	Percentage of triglycerides in IDL particles
Ile	Isoleucine
LA	18:2, linoleic acid
LA/FA	Ratio of 18:2, linoleic acids to total fatty acids
Lac	Lactate
LDL-C	Total cholesterol in LDL
LDL-D	Mean diameter for LDL particles
LDL-TG	Triglycerides in LDL
Leu	Leucine
L-HDL-C	Total cholesterol in large HDL particles
L-HDL-C_%	Percentage of cholesterol in large HDL particles
L-HDL-CE	Cholesterol esters in large HDL particles
L-HDL-CE_%	Percentage of cholesterol esters in large HDL particles
L-HDL-FC	Free cholesterol in large HDL particles
L-HDL-FC_%	Percentage of free cholesterol in large HDL particles
L-HDL-L	Total lipids in large HDL particles
L-HDL-P	Concentration of large HDL particles
L-HDL-PL	Phospholipids in large HDL particles
L-HDL-PL_%	Percentage of phospholipids in large HDL particles
L-HDL-TG	Triglycerides in large HDL particles
L-HDL-TG_%	Percentage of triglycerides in large HDL particles
L-LDL-C	Total cholesterol in large LDL particles
L-LDL-C_%	Percentage of cholesterol in large LDL particles
L-LDL-CE	Cholesterol esters in large LDL particles
L-LDL-CE_%	Percentage of cholesterol esters in large LDL particles
L-LDL-FC	Free cholesterol in large LDL particles
L-LDL-FC_%	Percentage of free cholesterol in large LDL particles
L-LDL-L	Total lipids in large LDL particles
L-LDL-P	Concentration of large LDL particles
L-LDL-PL	Phospholipids in large LDL particles
L-LDL-PL_%	Percentage of phospholipids in large LDL particles

L-LDL-TG	Triglycerides in large LDL particles
L-LDL-TG_%	Percentage of triglycerides in large LDL particles
L-VLDL-C	Total cholesterol in large VLDL particles
L-VLDL-C_%	Percentage of cholesterol in large VLDL particles
L-VLDL-CE	Cholesterol esters in large VLDL particles
L-VLDL-CE_%	Percentage of cholesterol esters in large VLDL particles
L-VLDL-FC	Free cholesterol in large VLDL particles
L-VLDL-FC_%	Percentage of free cholesterol in large VLDL particles
L-VLDL-L	Total lipids in large VLDL particles
L-VLDL-P	Concentration of large VLDL particles
L-VLDL-PL	Phospholipids in large VLDL particles
L-VLDL-PL_%	Percentage of phospholipids in large VLDL particles
L-VLDL-TG	Triglycerides in large VLDL particles
L-VLDL-TG_%	Percentage of triglycerides in large VLDL particles
M-HDL-C	Total cholesterol in medium HDL particles
M-HDL-C_%	Percentage of cholesterol in medium HDL particles
M-HDL-CE	Cholesterol esters in medium HDL particles
M-HDL-CE_%	Percentage of cholesterol esters in medium HDL particles
M-HDL-FC	Free cholesterol in medium HDL particles
M-HDL-FC_%	Percentage of free cholesterol in medium HDL particles
M-HDL-L	Total lipids in medium HDL particles
M-HDL-P	Concentration of medium HDL particles
M-HDL-PL	Phospholipids in medium HDL particles
M-HDL-PL_%	Percentage of phospholipids in medium HDL particles
M-HDL-TG	Triglycerides in medium HDL particles
M-HDL-TG_%	Percentage of triglycerides in medium HDL particles
M-LDL-C	Total cholesterol in medium LDL particles
M-LDL-C_%	Percentage of cholesterol in medium LDL particles
M-LDL-CE	Cholesterol esters in medium LDL particles
M-LDL-CE_%	Percentage of cholesterol esters in medium LDL particles
M-LDL-FC	Free cholesterol in medium LDL particles
M-LDL-FC_%	Percentage of free cholesterol in medium LDL particles
M-LDL-L	Total lipids in medium LDL particles
M-LDL-P	Concentration of medium LDL particles
M-LDL-PL	Phospholipids in medium LDL particles
M-LDL-PL_%	Percentage of phospholipids in medium LDL particles
M-LDL-TG	Triglycerides in medium LDL particles
M-LDL-TG_%	Percentage of triglycerides in medium LDL particles
MUFA	Monounsaturated fatty acids

MUFA/FA	Ratio of monounsaturated fatty acids to total fatty acids
M-VLDL-C	Total cholesterol in medium VLDL particles
M-VLDL-C_%	Percentage of cholesterol in medium VLDL particles
M-VLDL-CE	Cholesterol esters in medium VLDL particles
M-VLDL-CE_%	Percentage of cholesterol esters in medium VLDL particles
M-VLDL-FC	Free cholesterol in medium VLDL particles
M-VLDL-FC_%	Percentage of free cholesterol in medium VLDL particles
M-VLDL-L	Total lipids in medium VLDL particles
M-VLDL-P	Concentration of medium VLDL particles
M-VLDL-PL	Phospholipids in medium VLDL particles
M-VLDL-PL_%	Percentage of phospholipids in medium VLDL particles
M-VLDL-TG	Triglycerides in medium VLDL particles
M-VLDL-TG_%	Percentage of triglycerides in medium VLDL particles
PC	Phosphatidylcholine and other cholines
Phe	Phenylalanine
PUFA	Polyunsaturated fatty acids
PUFA/FA	Ratio of polyunsaturated fatty acids to total fatty acids
Remnant-C	Remnant cholesterol (non-HDL, non-LDL cholesterol)
Serum-C	Serum total cholesterol
Serum-TG	Serum total triglycerides
SFA	Saturated fatty acids
SFA/FA	Ratio of saturated fatty acids to total fatty acids
S-HDL-C	Total cholesterol in small HDL particles
S-HDL-C_%	Percentage of cholesterol in small HDL particles
S-HDL-CE	Cholesterol esters in small HDL particles
S-HDL-CE_%	Percentage of cholesterol esters in small HDL particles
S-HDL-FC	Free cholesterol in small HDL particles
S-HDL-FC_%	Percentage of free cholesterol in small HDL particles
S-HDL-L	Total lipids in small HDL particles
S-HDL-P	Concentration of small HDL particles
S-HDL-PL	Phospholipids in small HDL particles
S-HDL-PL_%	Percentage of phospholipids in small HDL particles
S-HDL-TG	Triglycerides in small HDL particles
S-HDL-TG_%	Percentage of triglycerides in small HDL particles
S-LDL-C	Total cholesterol in small LDL particles
S-LDL-C_%	Percentage of cholesterol in small LDL particles
S-LDL-CE	Cholesterol esters in small LDL particles
S-LDL-CE_%	Percentage of cholesterol esters in small LDL particles
S-LDL-FC	Free cholesterol in small LDL particles

S-LDL-FC_%	Percentage of free cholesterol in small LDL particles
S-LDL-L	Total lipids in small LDL particles
S-LDL-P	Concentration of small LDL particles
S-LDL-PL	Phospholipids in small LDL particles
S-LDL-PL_%	Percentage of phospholipids in small LDL particles
S-LDL-TG	Triglycerides in small LDL particles
S-LDL-TG_%	Percentage of triglycerides in small LDL particles
SM	Sphingomyelins
S-VLDL-C	Total cholesterol in small VLDL particles
S-VLDL-C_%	Percentage of cholesterol in small VLDL particles
S-VLDL-CE	Cholesterol esters in small VLDL particles
S-VLDL-CE_%	Percentage of cholesterol esters in small VLDL particles
S-VLDL-FC	Free cholesterol in small VLDL particles
S-VLDL-FC_%	Percentage of free cholesterol in small VLDL particles
S-VLDL-L	Total lipids in small VLDL particles
S-VLDL-P	Concentration of small VLDL particles
S-VLDL-PL	Phospholipids in small VLDL particles
S-VLDL-PL_%	Percentage of phospholipids in small VLDL particles
S-VLDL-TG	Triglycerides in small VLDL particles
S-VLDL-TG_%	Percentage of triglycerides in small VLDL particles
TG/PG	Ratio of triglycerides to phosphoglycerides
TotCho	Total cholines
TotFA	Total fatty acids
TotPG	Total phosphoglycerides
Tyr	Tyrosine
UnSat	Estimated degree of unsaturation
Val	Valine
VLDL-C	Total cholesterol in VLDL
VLDL-D	Mean diameter for VLDL particles
VLDL-TG	Triglycerides in VLDL
XL-HDL-C	Total cholesterol in very large HDL particles
XL-HDL-C_%	Percentage of cholesterol in very large HDL particles
XL-HDL-CE	Cholesterol esters in very large HDL particles
XL-HDL-CE_%	Percentage of cholesterol esters in very large HDL particles
XL-HDL-FC	Free cholesterol in very large HDL particles
XL-HDL-FC_%	Percentage of free cholesterol in very large HDL particles
XL-HDL-L	Total lipids in very large HDL particles
XL-HDL-P	Concentration of very large HDL particles
XL-HDL-PL	Phospholipids in very large HDL particles

XL-HDL-PL_%	Percentage of phospholipids in very large HDL particles
XL-HDL-TG	Triglycerides in very large HDL particles
XL-HDL-TG_%	Percentage of triglycerides in very large HDL particles
XL-VLDL-C	Total cholesterol in very large VLDL particles
XL-VLDL-C_%	Percentage of cholesterol in very large VLDL particles
XL-VLDL-CE	Cholesterol esters in very large VLDL particles
XL-VLDL-CE_%	Percentage of cholesterol esters in very large VLDL particles
XL-VLDL-FC	Free cholesterol in very large VLDL particles
XL-VLDL-FC_%	Percentage of free cholesterol in very large VLDL particles
XL-VLDL-L	Total lipids in very large VLDL particles
XL-VLDL-P	Concentration of very large VLDL particles
XL-VLDL-PL	Phospholipids in very large VLDL particles
XL-VLDL-PL_%	Percentage of phospholipids in very large VLDL particles
XL-VLDL-TG	Triglycerides in very large VLDL particles
XL-VLDL-TG_%	Percentage of triglycerides in very large VLDL particles
XS-VLDL-C	Total cholesterol in very small VLDL particles
XS-VLDL-C_%	Percentage of cholesterol in very small VLDL particles
XS-VLDL-CE	Cholesterol esters in very small VLDL particles
XS-VLDL-CE_%	Percentage of cholesterol esters in very small VLDL particles
XS-VLDL-FC	Free cholesterol in very small VLDL particles
XS-VLDL-FC_%	Percentage of free cholesterol in very small VLDL particles
XS-VLDL-L	Total lipids in very small VLDL particles
XS-VLDL-P	Concentration of very small VLDL particles
XS-VLDL-PL	Phospholipids in very small VLDL particles
XS-VLDL-PL_%	Percentage of phospholipids in very small VLDL particles
XS-VLDL-TG	Triglycerides in very small VLDL particles
XS-VLDL-TG_%	Percentage of triglycerides in very small VLDL particles
XXL-VLDL-C	Total cholesterol in chylomicrons and extremely large VLDL particles
XXL-VLDL-C_%	Percentage of cholesterol in chylomicrons and extremely large VLDL particles
XXL-VLDL-CE	Cholesterol esters in chylomicrons and extremely large VLDL particles
XXL-VLDL-CE_%	Percentage of cholesterol esters in chylomicrons and extremely large VLDL particles
XXL-VLDL-FC	Free cholesterol in chylomicrons and extremely large VLDL particles
XXL-VLDL-FC_%	Percentage of free cholesterol in chylomicrons and extremely large VLDL particles
XXL-VLDL-L	Total lipids in chylomicrons and extremely large VLDL particles
XXL-VLDL-P	Concentration of chylomicrons and extremely large VLDL particles
XXL-VLDL-PL	Phospholipids in chylomicrons and extremely large VLDL particles

XXL-VLDL-PL_%	Percentage of phospholipids in chylomicrons and extremely large VLDL particles
XXL-VLDL-TG	Triglycerides in chylomicrons and extremely large VLDL particles
XXL-VLDL-TG_%	Percentage of triglycerides in chylomicrons and extremely large VLDL particles

Supplementary Table 2: Significant correlations between metabolites and clinical scores. Correlations between metabolites and patient clinical characteristics (Figure 4). Pearson's product moment correlation coefficients and p values in brackets. Only correlations with p value below 0.05 are shown.

	Disease Duration	GSM	BILAG	Plaque Number	Total Plaque Thickness	TPA
L.VLDL.TG:Lac	NA	NA	NA	NA	NA	0.371 (0.043)
IDL.CE:Glol	NA	0.411 (0.024)	NA	NA	NA	NA
XL.HDL.TG:Glol	NA	0.439 (0.015)	NA	NA	NA	NA
DHA.FA:Age	NA	NA	-0.386 (0.034)	NA	NA	NA
Gly:XS.VLDL.CE_%	NA	-0.444 (0.013)	NA	NA	NA	NA
His:XS.VLDL.CE_%	NA	-0.398 (0.029)	NA	-0.377 (0.039)	-0.392 (0.032)	NA
Tyr:Dis_Dur	0.913 (<0.00001)	NA	NA	NA	NA	NA
M.VLDL.FC_.: L.LDL.FC_%	NA	NA	0.369 (0.044)	NA	NA	NA
LDL-D	NA	-0.438 (0.015)	NA	NA	NA	NA
XS-VLDL-TG	NA	0.479 (0.007)	NA	NA	NA	NA
S-HDL-TG	NA	0.493 (0.005)	NA	NA	NA	NA
M-VLDL-FC_%	NA	NA	0.384 (0.036)	NA	NA	NA

2 Supplementary Figures

Logistic Regression

Actual \ Predicted	NP	P	Σ
NP	43	7	50
P	13	17	30
Σ	56	24	80

Logistic Regression + Interactions

Actual \ Predicted	NP	P	Σ
NP	44	6	50
P	10	20	30
Σ	54	26	80

SVM

Actual \ Predicted	NP	P	Σ
NP	42	8	50
P	18	12	30
Σ	60	20	80

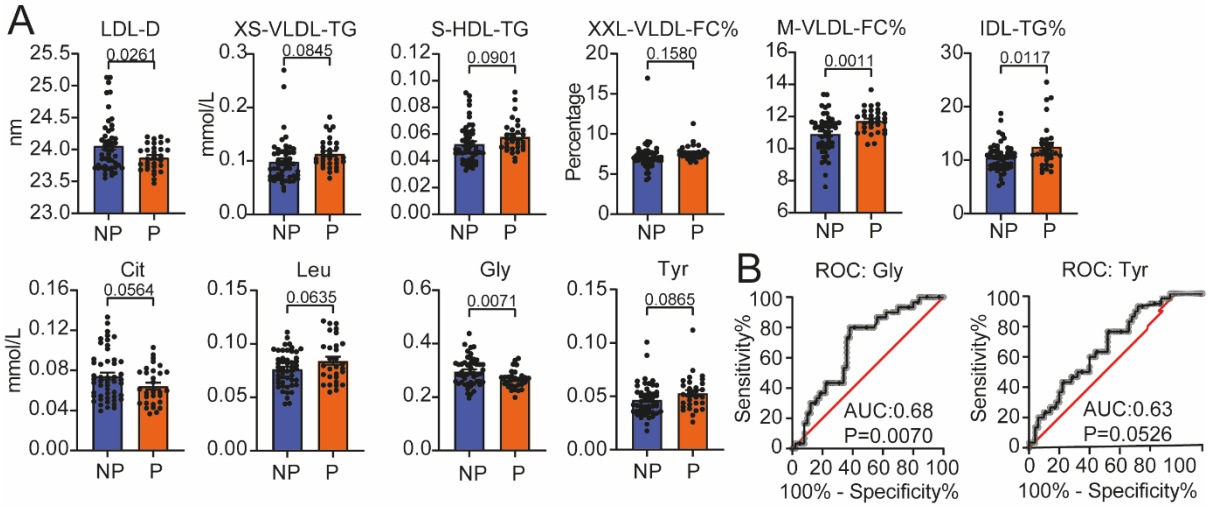
Random Forest

Actual \ Predicted	NP	P	Σ
NP	45	5	50
P	17	13	30
Σ	62	18	80

Decision Tree

Actual \ Predicted	NP	P	Σ
NP	37	13	50
P	15	15	30
Σ	52	28	80

Supplementary Figure 1: Confusion Matrices. The confusion matrix shows the number of correct (blue squares) and incorrect (orange squares) classifications for each model. The sum (Σ) of each row and column is given. The algorithms used were lasso logistic regression (LR), logistic regression with interactions (LR+I), support vector machine (SVM), random forest (RF), and decision tree (Tree). Performance metrics in table 2 for all five models are based on these confusion matrices.



Supplementary Figure 2. Identification of important metabolites separating patients with SLE-P from SLE-NP. (**A)** Bar graphs showing metabolite levels between SLE-P and SLE-NP for each metabolite identified by univariate logistic regression, random forest (RF), Lasso logistic regression (LR) analysis (see Figure 2A-C). Mean, T tests and p values shown. **(B).** Metabolites which featured in the top ten of LR and RF were further analysed in a ROC plot (See Figure 2B and 2D).

3 Supplementary Data Files

Supplementary Data File 1

Excel file containing the correlation matrix used for homology reduction.

Supplementary Data File 2

Lists of predictors for the support vector machine (SVM), random forest (RF), and logistic regression (LR) models. These lists include both metabolic and clinical/demographic predictors. For LR models negative beta-coefficients indicate a reduced likelihood of plaque development.

Supplementary Data File 3

Excel spreadsheet containing the results of logistic regression for individual metabolites, accompanying Supplementary Figure 4. P-values <0.05 are given in red text.

Supplementary Data File 4

PDF containing the forest plot visualization of the results of the logistic regression for individual metabolites. P-values <0.05 are given in coloured in circles.