

Supplementary materials to:

PET/MRI-evaluated activation of brown adipose tissue via cold exposure impacts lipid metabolism

Katarzyna Miniewska^{1,*}, Katarzyna Maliszewska², Karolina Pietrowska¹, Joanna Godzien¹, Łukasz Łabieniec³, Małgorzata Mojsak⁴, Adam Krętowski^{2,5}, Michał Ciborowski^{1,*}

¹ Laboratory of Metabolomics, Clinical Research Centre, Medical University of Białystok, Marii Skłodowskiej-Curie 24A, 15-276 Białystok, Poland; karolina.pietrowska@umb.edu.pl (K.P.); joanna.godzien@umb.edu.pl (J.G.)

² Department of Endocrinology, Diabetology and Internal Medicine, Medical University of Białystok, Marii Skłodowskiej-Curie 24A, 15-276 Białystok, Poland; katarzyna.maliszewska@umb.edu.pl (K.Ma.); adam.kretowski@umb.edu.pl (A.K.)

³ Department of Condensed Matter Physics, University of Białystok, Konstantego Ciołkowskiego 1L, 15-245 Białystok, Poland; lukaszlabieniec@gmail.com (Ł.Ł.)

⁴ Independent Laboratory of Molecular Imaging, Medical University of Białystok, Zurawia 71A, 15-540, Białystok, Poland; malgorzata.mojsak@umb.edu.pl (M.M.)

⁵ Clinical Research Centre, Medical University of Białystok, Marii Skłodowskiej-Curie 24A, 15-276 Białystok, Poland

* Correspondence: katarzyna.miniewska@umb.edu.pl (K.Mi.); michal.ciborowski@umb.edu.pl (M.C.)

Table S1. Plasma metabolites discriminating samples collected during cold exposure from the samples collected at the beginning of the procedure.

Metabolite	Percentage of change			
	60 minutes of CE vs. before CE		120 minutes of CE vs. before CE	
	BAT (+) (absolute p(corr); VIP)	BAT (-) (absolute p(corr); VIP)	BAT (+) (absolute p(corr); VIP)	BAT (-) (absolute p(corr); VIP)
L2 annotations				
A, Phospholipids				
LPC(16:0) sn-2	NS	NS	-9.8 (0.4; 1.3)	2.2 (NS)
LPC(16:0) sn-1	NS	NS	-9.0 (0.5; 1.4)	1.7 (NS)
LPC(17:0)	61.4 (0.5; 2.4)	4.7 (NS)	NS	NS
LPC(18:0)	-27.5 (0.4; 2.6)	-11.9 (NS)	-15.6 (0.5; 1.8)	10.9 (NS)
LPC(18:2) sn-2	NS	NS	-15.7 (0.5; 1.9)	-4.7 (NS)
LPC(18:2) sn-1	NS	NS	-10.8 (0.4; 1.4)	-3.7 (NS)
LPE(16:0)	NS	NS	40.4 (0.4; 2.3)	41.4 (NS)
LPE(20:4)	93.2 (0.4; 2.5)	10.5 (NS)	18.1 (0.4; 1.5)	13.1 (NS)
LPE(22:4)	NS	NS	34.3 (0.4; 1.9)	11.6 (NS)
LPE(22:6)	NS	NS	29.2 (0.4; 1.8)	-1.4 (NS)
B, Other metabolites				
Citric acid	NS	NS	22.9 (0.4; 1.7)	26.6 (NS)
Lactic acid	-26.6 (0.5; 2.7)	-6.8 (NS)	-22.2 (0.5; 2.3)	-9.6 (NS)
Sphinganine-phosphate	-40.4 (0.8; 4.0)	-10.5 (NS)	-31.9 (0.7; 3.2)	-1.7 (NS)
L2/L3 annotations				
(d18:2) sphingosine	-26.6 (0.7; 2.9)	-14.9 (NS)	-17.1 (0.5; 2.0)	2.9 (NS)
Arachidonic acid	43.6 (0.4; 2.3)	29.3 (NS)	68.7 (0.6; 3.2)	40.7 (NS)
Cholic acid	-12.9 (0.4; 3.2)	35.4 (NS)	-58.3 (0.7; 5.2)	-31.2 (NS)
DHA	42.2 (0.4; 2.2)	6.1 (NS)	55.8 (0.5; 2.6)	15.5 (NS)
Hydroxyoctadecanoic acid (FA 18:0-OH)	13.4 (0.5; 1.4)	11.8 (NS)	13.1 (0.5; 1.4)	7.2 (NS)
Linoleic acid	NS	NS	37.1 (0.5; 2.3)	7.9 (NS)
LPA(O-18:3);O	-32.6 (0.6; 3.1)	-21.5 (NS)	-27.7 (0.6; 2.8)	-22.3 (NS)
Oleic acid	NS	NS	28.4 (0.5; 1.8)	2.6 (NS)
Palmitic acid	25.3 (0.5; 2.0)	16.3 (NS)	27.0 (0.6; 2.0)	27.9 (NS)
Sphingosine-1-phosphate	-32.4 (0.7; 3.4)	-8.8 (NS)	NS	NS

Table S2. Plasma metabolites discriminating BAT(+) group from BAT(-) group after 60 and 120 minutes of cold exposure.

Metabolite	Percentage of change	
	60 minutes of CE BAT (+) vs. BAT (-) (absolute p(corr); VIP)	120 minutes of CE BAT (+) vs. BAT (-) (absolute p(corr); VIP)
L2 annotations		
A, Phospholipids		
LPC(16:0) sn-2	NS	-22.0 (0.5; 1.9)
LPC(16:0) sn-1	NS	-10.3 (0.5; 1.1)
LPC(16:1)	-9.9 (0.4; 1.8)	NS
LPC(17:0)	-11.7 (0.5; 2.0)	NS
LPC(18:0) sn-2	34.6 (0.4; 1.4)	-21.2 (0.5; 2.0)
LPC(18:0) sn-1	-22.1 (0.4; 1.3)	-15.4 (0.4; 1.6)
LPC(18:1)	-12.6 (0.4; 1.3)	NS
LPC(20:1)	NS	-22.8 (0.4; 1.8)
LPC(20:2)	NS	-19.9 (0.4; 1.6)
LPC(20:5)	NS	-46.3 (0.4; 2.3)
LPC(O-16:0)	-13.8 (0.4; 1.5)	-18.0 (0.5; 1.6)
LPC(O-18:1) / LPC(P-18:0)	NS	-25.7 (0.4; 1.8)
LPE(O-16:1) / LPE(P-16:0)	NS	-26.6 (0.5; 2.2)
LPE(O-18:0)	43.4 (0.5; 1.8)	NS
LPE(O-18:1) / LPE(P-18:0)	NS	-22.4 (0.4; 1.8)
LPE(O-18:2) / LPE(P-18:1)	NS	-28.3 (0.5; 2.1)
PC(36:3)	NS	-24.1 (0.6; 2.0)
SM(d35:1)	NS	31.2 (0.5; 1.8)
SM(d42:2)	NS	24.8 (0.4; 2.0)
B, Other metabolites		
9-HpODE	66.9 (0.5; 2.2)	61.0 (0.6; 2.6)
Acetylcarnitine	NS	28.5 (0.4; 2.0)
L2/L3 annotations		
Hexacosanedioic acid	NS	-29.3 (0.4; 1.8)
Hydroxyoctadecanoic acid	39.4 (0.5; 1.7)	21.9 (0.6; 1.8)
Linoleic acid	37.1 (0.6; 3.4)	NS
Oleic acid	19.3 (0.5; 2.5)	59.7 (0.7; 3.1)
Palmitic acid	35.1 (0.6; 2.5)	29.6 (0.7; 3.6)

Table S3. Annotation of plasma metabolites significantly associated with BAT activation

Metabolite	RT (min)	Fragments
A, Lipids		
LPA(O-18:3);O	6.1	N: 433.235, 152.996, 78.959
LPC(14:0)	5.0	N: 512.299, 452.279, 227.202, 224.071 P: 468.308, 450.297, 184.073, 166.034, 125.000, 104.107
LPC(15:0)	5.2	N: 526.315, 466.294, 241.217, 224.069, 168.041 P: 482.323, 464.312, 184.073, 166.061, 124.998, 104.107
LPC(16:0) sn-2	5.5	N: 540.331, 480.309, 255.233 P: 496.340, 184.073
LPC(16:0) sn-1	5.6	N: 540.331, 480.311, 255.233, 224.070, 168.043 P: 496.340, 184.073, 166.062, 125.000, 104.070
LPC(16:1) sn-2	5.0	N: 538.315, 478.293, 253.217
LPC(16:1) sn-1	5.2	N: 538.315, 478.294, 253.217, 224.069, 168.043
LPC(17:0)	5.7	N: 554.344, 494.326, 269.249, 224.070, 168.042
LPC(17:1)	5.4	N: 552.330, 492.309, 267.233, 224.069
LPC(18:0) sn-2	6.1	N: 568.362, 508.342, 283.265, 224.070, 168.043
LPC(18:0) sn-1	6.2	N: 568.362, 508.341, 283.265, 224.067, 168.043
LPC(18:1)	5.8	N: 566.346, 506.326, 281.249, 224.069, 168.042
LPC(18:2) sn-2	5.3	N: 564.331, 504.310, 279.233, 168.041 P: 520.341, 184.073, 166.062, 125.000, 104.107
LPC(18:2) sn-1	5.4	N: 564.331, 504.312, 279.233, 224.069, 168.043 P: 520.341, 502.328, 184.073, 166.062, 125.000, 104.107
LPC(19:0)	6.5	N: 582.377, 522.359, 297.279, 224.071
LPC(19:1)	6.0	N: 580.361, 520.340, 295.265, 224.072
LPC(20:0)	6.8	N: 596.393, 536.374, 311.296, 224.070
LPC(20:1)	6.3	N: 594.377, 534.356, 309.279, 224.068
LPC(20:2)	5.9	N: 592.362, 532.342, 307.264, 224.069
LPC(20:4)	5.4	N: 578.301, 528.311, 303.233, 242.083, 168.043
LPC(20:5)	5.1	N: 586.315, 526.296, 301.217, 224.070
LPC(O-16:0)	5.7	N: 526.351, 466.330, 224.068, 168.044
LPC(O-18:1) / LPC(P-18:0)	5.9	N: 552.367, 492.346

LPC(O-18:2) / LPC(P-18:1)	5.9	N: 550.351, 490.329
LPC(16:0)-OH	5.1	P: 512.334, 184.073, 146.983, 125.000, 104.107
LPE(16:0)	5.5	N: 452.278, 255.233, 196.038 P: 454.292, 313.234, 282.281
LPE(18:0)	6.2	N: 480.309, 283.265, 214.049, 196.037
LPE(20:4)	5.4	N: 500.278, 303.233, 214.049, 196.038
LPE(22:4)	5.8	N: 528.309, 331.266, 196.040
LPE(22:6)	5.3	N: 592.265, 524.280, 327.234, 283.244, 196.039
LPE(O-16:1) / LPE(P-16:0)	5.7	N: 436.283, 196.036, 140.012
LPE(O-18:0)	5.7	N: 466.329, 196.038, 168.041
LPE(O-18:1) / LPE(P-18:0)	6.3	N: 464.314, 196.037, 140.012
LPE(O-18:2) / LPE(P-18:1)	5.9	N: 462.299, 196.038, 140.011
LPE(O-20:1) / LPE(P-20:0)	5.9	N: 492.346, 168.041
LPI(18:0)	6.8	N: 599.320, 315.046, 283.264, 241.015, 152.995
PC(16:0_18:3)	9.1	N: 800.544, 740.524, 277.217, 255.233, 168.042
PC(16:0_22:6)	9.3	N: 840.532, 790.541, 480.309, 327.232, 283.244, 255.231
PC(36:3)	9.7	N: 900.506, 116.929
PC(36:4)	9.1	N: 894.547, 112.985
PC(36:5)	9.0	N: 892.532, 112.985 P: 780.554, 184.073, 166.058, 125.000
PC(38:5)	9.8	N: 924.506, 116.928
PC(O-16:1_18:2) / PC(P-16:0_18:2)	9.9	N: 786.565, 726.545, 279.232
SM(d32:2)	7.4	N: 717.519, 657.498, 168.043
SM(d35:1)	9.0	N: 761.581, 701.561, 168.043
SM(d35:2)	8.5	N: 759.565, 699.547, 168.043
SM(d42:2)	7.5	P: 835.666, 776.593, 652.598, 184.072, 146.982
B, Other metabolites		
(d18:2) sphingosine	4.5	N: 376.225, 78.960
9-HpODE	5.4	N: 311.223, 293.212, 249.221
Acetylcarnitine	0.2	P: 204.124, 145.049, 85.028, 60.081

Arachidonic acid	7.0	N: 303.233, 259.242, 205.197, 59.013
Bilirubin	4.9	N: 583.256, 285.125, 253.136
Cholic acid	4.2	N: 407.280
DHA	6.9	N: 327.233, 283.243, 229.196, 59.014
FA 12:4;O3	3.5	N: 239.093, 195.103, 151.113
Hexacosanedioic acid	7.8	N: 425.363, 407.353, 363.360
Hydroxyoctadecanoic acid (FA 18:0-OH)	7.3	N: 299.259, 253.254
Histidine	0.2	N: 154.062, 137.035, 110.072, 93.045, 72.009
Linoleic acid	7.0	N: 279.233
Oleic acid	7.5	N: 281.249
Palmitic acid	7.4	N: 255.233
Sphingosine-1-phosphate	4.9	N: 446.228, 378.240, 78.959
ST 19:1;O2;S (dihydrotestosterone sulfate)	3.9	N: 367.158, 96.960