

Metabolic Health is Associated with Fat Oxidation During Exercise in Young Adults

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Abstract

BACKGROUND: The combination of traditional risk factors into a metabolic health score better represents cardiometabolic disease risk than the risk factors alone. Metabolic flexibility is the capacity to respond to metabolic demand and is associated with better health. Maximal fat oxidation during exercise, the highest rate of fat the body can use as fuel and the exercise intensity at which this occurs, are alternative measures of metabolic flexibility. **PURPOSE:** To compare measures of metabolic flexibility during exercise in young adults who are metabolically healthy and unhealthy. **METHODS:** Young adults (n = 27, 15 females, Age 24 ± 5 yrs., BMI = 27.2 ± 4.5) without overt cardiometabolic pathology completed a graded exercise test on a cycle ergometer to volitional exhaustion. Respiratory gases were measured during the test to assess the rate of fat oxidation during exercise. A third-degree polynomial was used to determine the highest rate of fat oxidation (peak fat oxidation; PFO) and the relative exercise intensity at PFO (PFO_{REL%}). Percent body fat and fat-free mass (FFM) were measured via dual X-ray absorptiometry (DXA). Metabolic health was scored according to five criteria: low cardiorespiratory fitness (VO2peak ≤ 50th percentile); glucose dysfunction (i.e., impaired glucose tolerance during an oral glucose tolerance test (OGTT) or hemoglobin A1c ≥ 5.7%); insulin resistance via Matsuda Index during the OGTT; elevated body fat percentage via DXA; and systemic inflammation (serum C-reactive protein > 1.0 mg/L). People who met two or more criteria were considered metabolically unhealthy. An α = 0.05 was determined a priori. Simple linear regression was used to test the association between metabolic health score and exercise metabolic flexibility. **FINDINGS:** Results are presented as mean ± SD. As expected, BMI is significantly higher in young adults who are metabolically unhealthy (29.3 ± 4.6 vs. 24.8 ± 3.2; p = 0.007) without differences in age (22.6 ± 5.5 vs. 24.9 ± 4.0 yrs.; p = 0.443) or fat-free mass (55.2 ± 10.1 vs. 47.4 ± 10.1 kg; p = 0.052). Metabolic health score is not associated with PFO (p = 0.456) or PFO_{REL%} (p = 0.453). When normalized to fat free mass (FFM), metabolic health score is associated with PFO (p = 0.033) but not PFO_{REL%} (p = 0.068). **CONCLUSION:** In response to exercise, people with worse metabolic health have a reduced ability to elevate fat oxidation when accounting for skeletal muscle mass, indicating reduced metabolic flexibility during exercise.

Background

The combination of traditional risk factors into a metabolic health score better represents cardiometabolic disease risk than the risk factors alone.

Metabolic flexibility

- Capacity to respond to metabolic demand
- Associated with better health outcomes

Maximal fat oxidation during exercise

- Highest rate of fat the body can use as fuel
- Alternative measures of metabolic flexibility
 - Maximal/peak fat oxidation (PFO)
 - Intensity at which PFO occurs (PFO_{REL%})

Purpose

Compare measures of metabolic flexibility during exercise between young adults who are metabolically healthy and unhealthy.

Methods

1. Participants

- Young adults (n = 27, 15 females, 24 ± 5 yrs., BMI: 27.2 ± 4.5)
- No overt cardiometabolic pathology
- Body fat % (BF%) and fat free mass (FFM) measured via DXA

2. Peak Fat Oxidation

- Graded exercise test (GXT) on cycle ergometer
- VO₂ and VCO₂ measured to assess rate of fat oxidation
- Third-degree polynomial used to determine PFO and PFO_{REL%}

Methods

3. Metabolic Health Score (2+ criteria = “unhealthy”)

- Low cardiorespiratory health
 - VO₂ peak ≤ 50th percentile
- Glucose Dysfunction
 - Hemoglobin A1c ≥ 5.7%
 - Impaired glucose tolerance during an oral glucose tolerance test (OGTT)
- Insulin Resistance
 - Matsuda Index from OGTT
- Elevated BF%
 - ≥ 27% for males or ≥ 44% for females
 - Obesity by BMI (≥ 30.0)
- Systemic inflammation
 - Serum C-Reactive Protein > 1.0 mg/L

4. Analyses

- Simple linear regression to test the association between metabolic health score and exercise metabolic flexibility

Results

Table 1. Absolute and relative peak fat oxidation, %VO2 max at PFO, body weight and composition

	Overall (n=27)	Healthy (n=13)	Unhealthy (n=14)	p
PFO (g/min)	0.465 (0.135)	0.467 (0.110)	0.463 (0.159)	0.948
PFO (g/min/10 kg FFM)	0.093 (0.026)	0.101 (0.026)	0.084 (0.024)	0.089
%VO2max at PFO (g/min)	50.226 (10.606)	51.746 (11.861)	48.814 (9.522)	0.484
%VO2max at PFO (g/min/10 kg FFM)	1.038 (0.335)	1.161 (0.374)	0.923 (0.255)	0.063
Relative VO2max (mL/kg/min)	34.4 (8.9)	39.7 (7.8)	29.6 (7.0)	0.002
Sex (n, % male)	12 (44.4)	4 (30.8)	8 (57.1)	0.322
Age (yrs)	22 [19, 27]	21 [19, 24]	24 [22, 28]	0.073
Weight (kg)	73.0 [66.6, 90.0]	67.4 [63.0, 72.7]	89.3 [75.0, 96.9]	0.003
Height (m)	1.71 (0.093)	1.68 (0.086)	1.73 (0.096)	0.217
BMI (kg/m2)	26.2 [24.1, 31.4]	24.7 [22.1, 26.2]	30.6 [24.8, 32.7]	0.017
BMI classification (n, %)				0.025
NW	12 (44.4)	8 (61.5)	4 (28.6)	
OW	6 (22.2)	4 (30.8)	2 (14.3)	
OB	9 (33.3)	1 (7.7)	8 (57.1)	
Fat-free mass (kg)	51.4 (10.4)	47.4 (9.5)	55.2 (10.1)	0.052
Fat mass (kg)	24.7 (9.4)	19.9 (7.6)	29.1 (8.9)	0.008
Body fat (%)	30.8 (8.2)	28.3 (8.3)	33.1 (7.7)	0.130
VAT mass (kg)	0.345 [0.113, 0.800]	0.109 [0.036, 0.236]	0.77 [0.45, 0.90]	0.001

Data presented as mean (SD) or median [IQR] depending on normality. Metabolic classification compared via t-test or Mann-Whitney U test

BMI

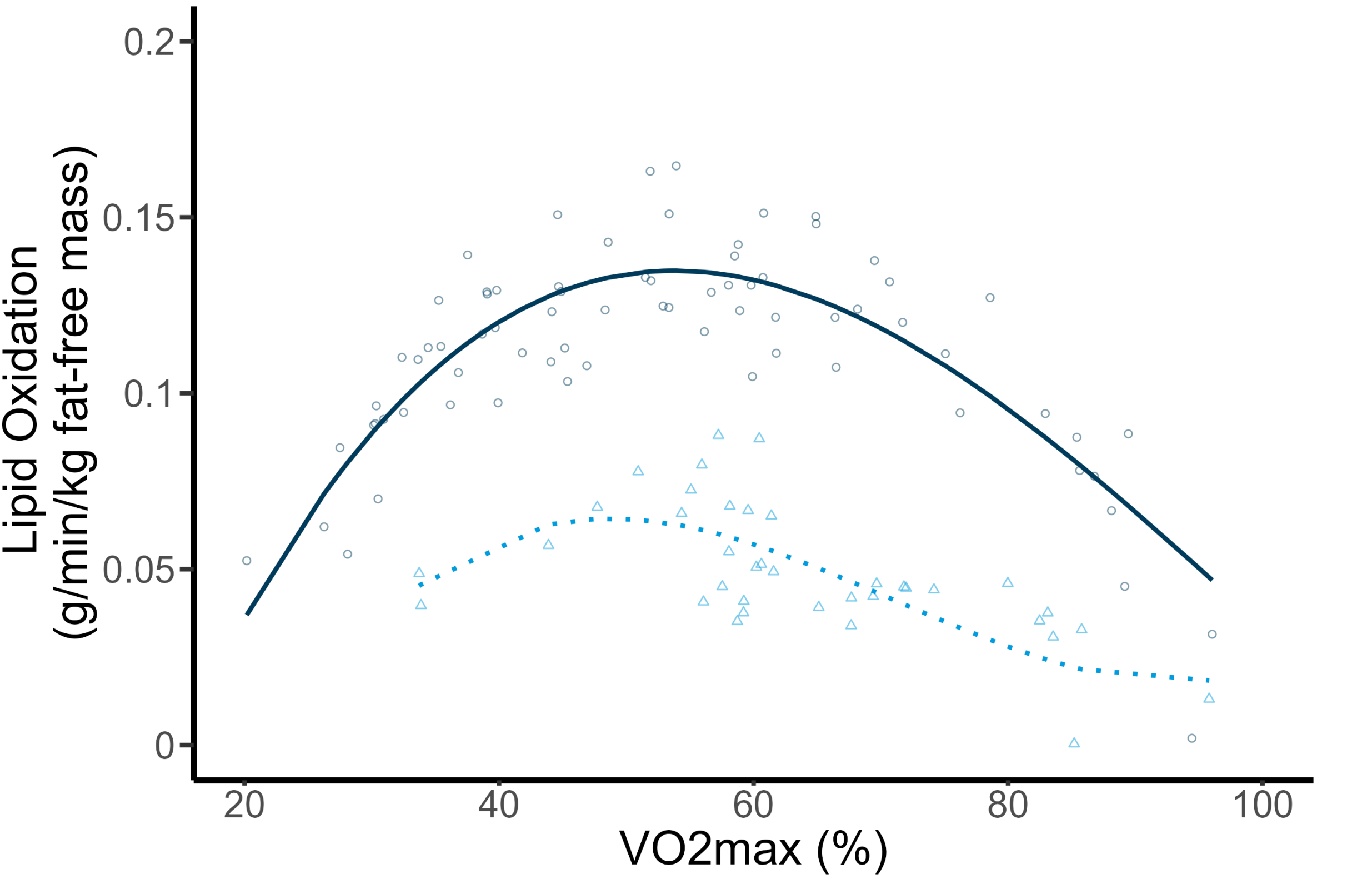
- BMI was significantly higher in unhealthy subjects without differences in age or FFM

Metabolic Health Score

- Not associated with PFO nor PFO_{REL%}
- When normalized to FFM, metabolic health score is associated with PFO but not PFO_{REL%}

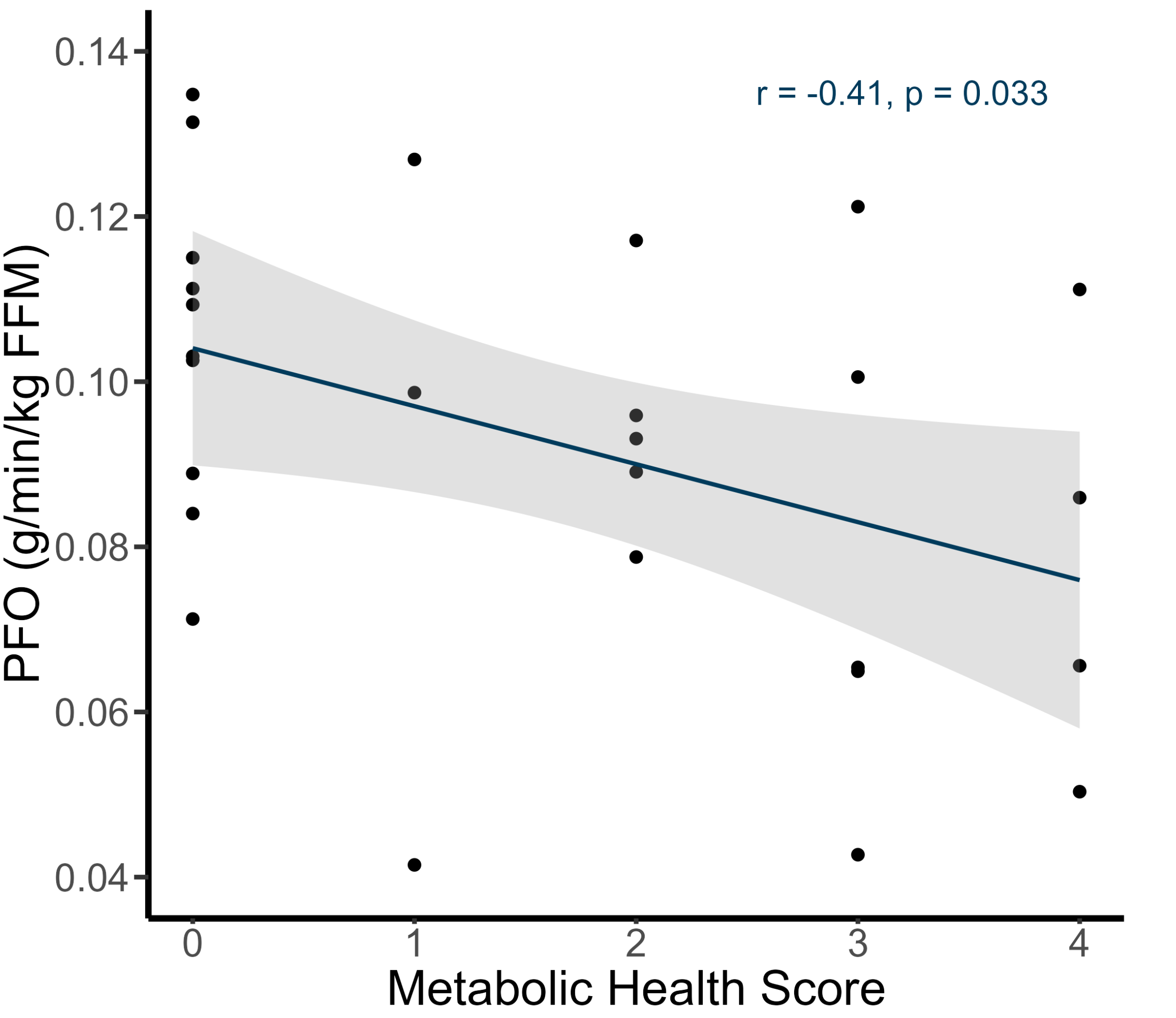
Results

Figure 1. Examples of fat oxidation through the course of the GXT (metabolically healthy vs **unhealthy**)



- Greater fat oxidation capabilities per unit of metabolically active tissue for metabolically healthy subjects

Figure 2. Metabolic health score and PFO normalized to FFM



- Lower metabolic health score is associated with greater peak fat oxidation capabilities

Individuals with a greater number of cardiovascular risk factors exhibit diminished metabolic flexibility during exercise when accounting for metabolically active tissue.