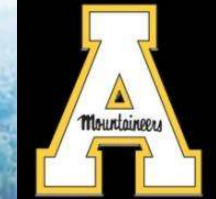




**MISSION:**  
**Scientific Discovery Leading to  
Improved Health and Performance**

Director: David C. Nieman, DrPH, FACSM;  
[www.ncrc.appstate.edu](http://www.ncrc.appstate.edu)

# North Carolina Research Campus, Kannapolis, NC 28081



David H. Murdock  
Research Institute

Cannon  
Village



Plants for Human  
Health Institute

Nutrition Research  
Institute

Human Performance Laboratory

APPALACHIAN STATE UNIVERSITY

# Research Focus: ASU-NCRC HPL



## Nutrition & lifestyle countermeasures to:

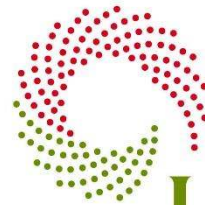
1. exercise- (ACUTE)
  2. obesity- (CHRONIC)
- induced:

- immune dysfunction
- inflammation
- oxidative stress





HERBALIFE.

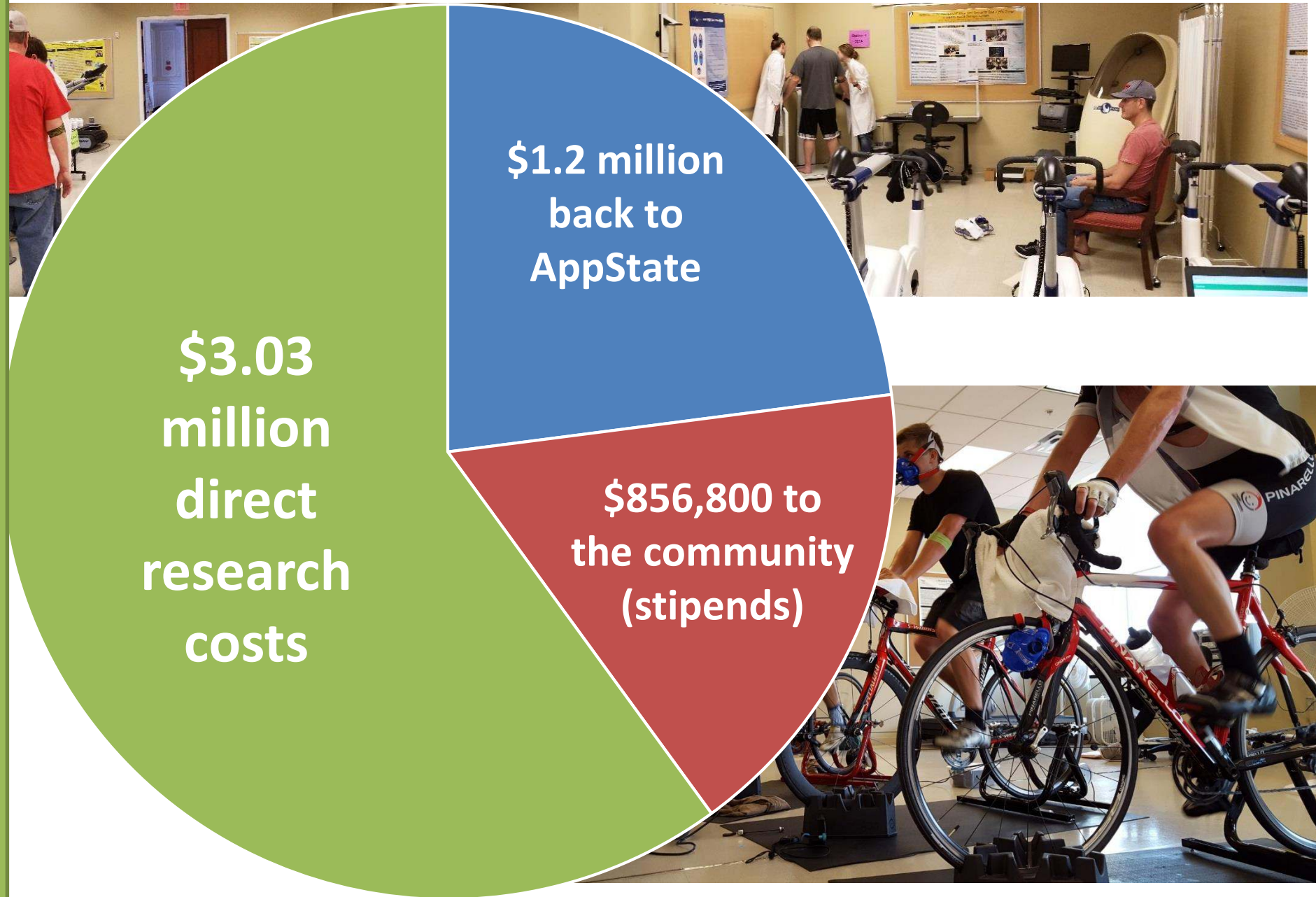


Direct Digital  
Leader in digital marketing



## AppState Research, 2009-2018, \$5.04 million Industry External Funding

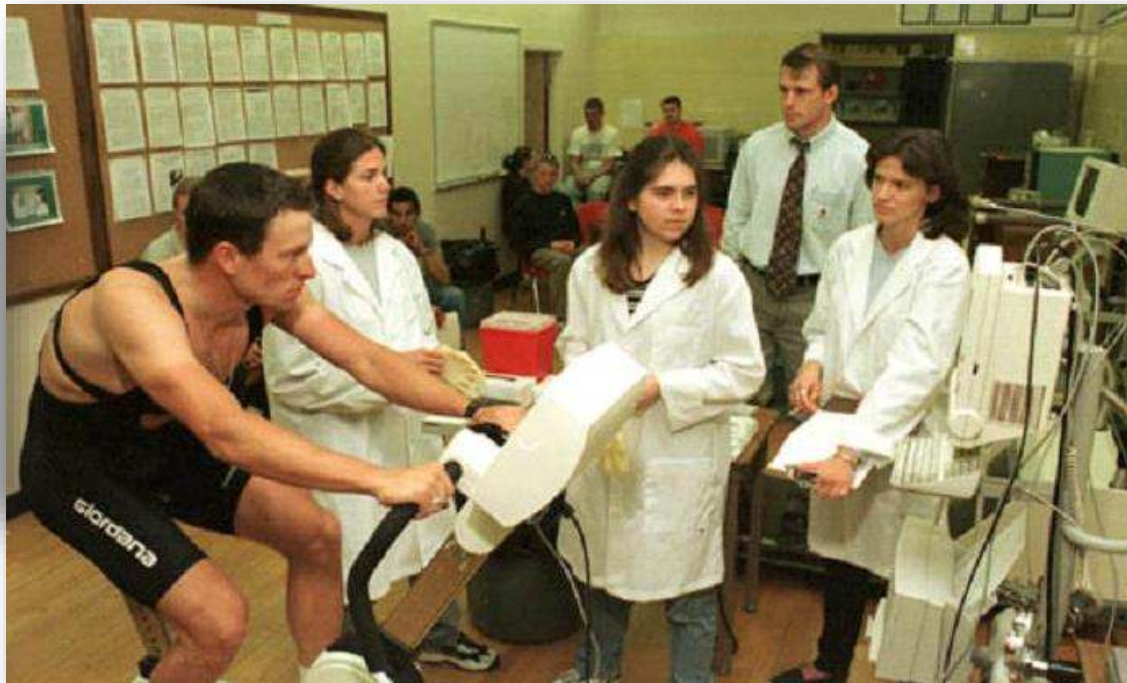
- 100 scientific papers (1/month)
- Novel scientific discoveries (PR)
  - *Moderate exercise reduces cold incidence*
  - *45-min vigorous exercise increases metabolism 14 h*
  - *Banana fruit ingestion by athletes dampens inflammation and COX-2 mRNA*
- 75 graduate students, interns, and international scholars

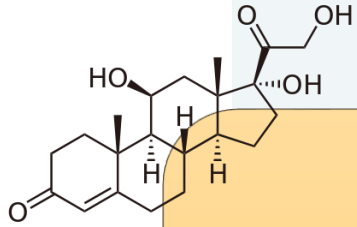


# Scientific Discovery Philosophy

- ✓ Double-blinded, placebo controlled research designs.
- ✓ Collaboration.
- ✓ Use of advanced technologies (*metabolomics, genomics, proteomics, biopsies, ultrasound, metabolic chamber*)

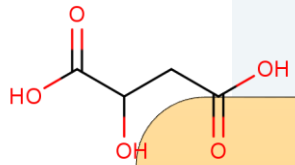






## Stress Biomarkers:

Elevated stress hormones, oxidative stress, tissue damage, inflammation

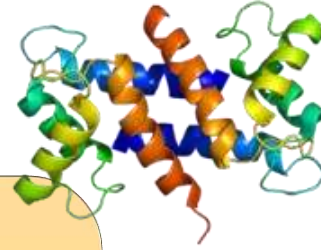


## Metabolomics:

Extensive and sustained shifts in lipid and Krebs Cycle metabolites

## Innate Immune System:

Dysfunction, activation of NK cells, neutrophils, macrophages



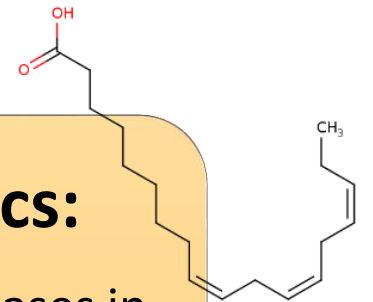
## Proteomics:

Large-fold increases in proteins related to inflammation and phagocyte migration

## Physiological Stress from Prolonged and Intensive Exercise

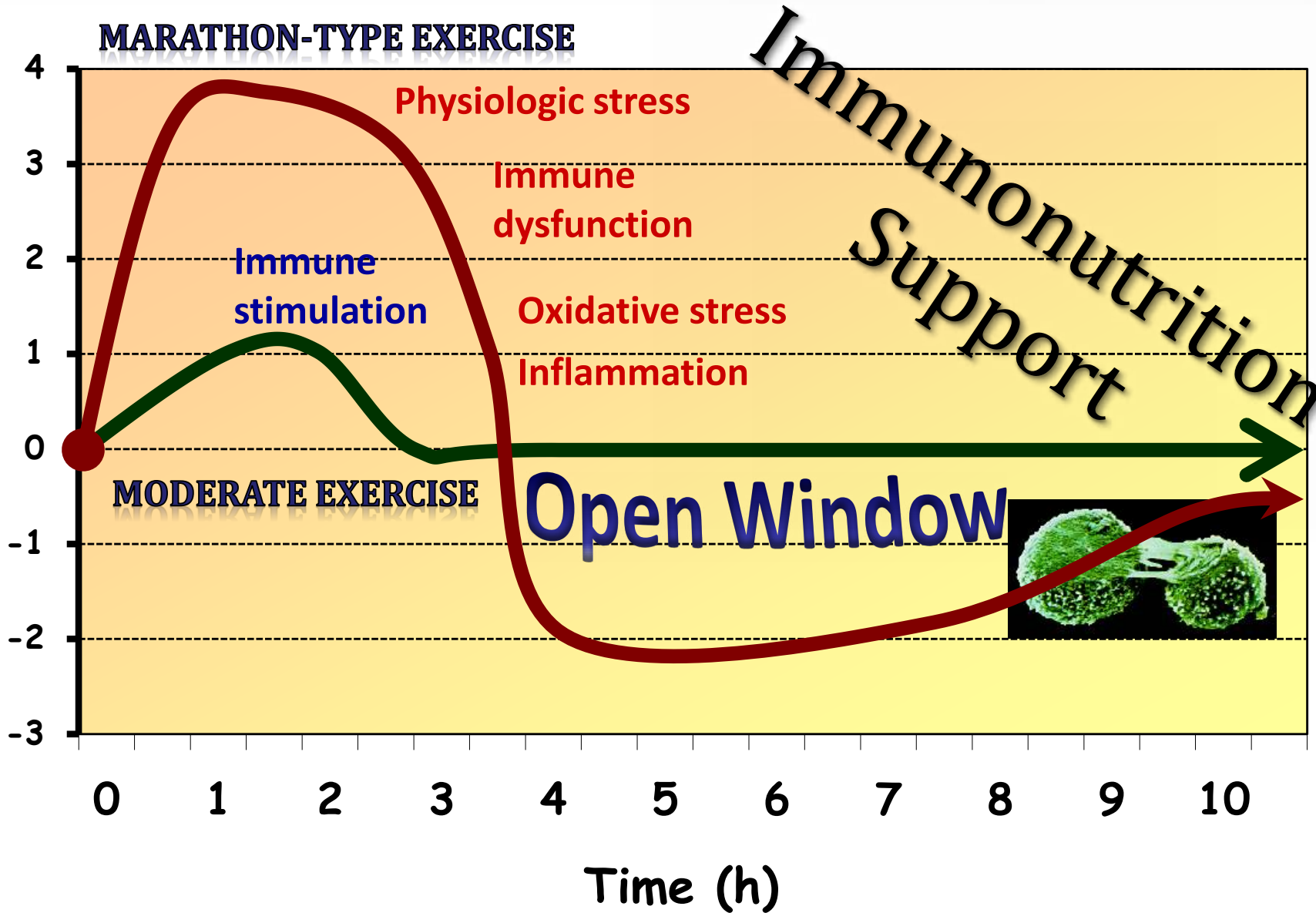
## Lipidomics:

Large-fold increases in PUFA-lipid mediators





# Relationship Between Exercise Workload and Immune Response, and Immunonutrition Support



## METABOLOMICS

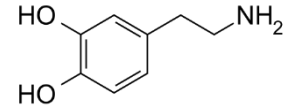
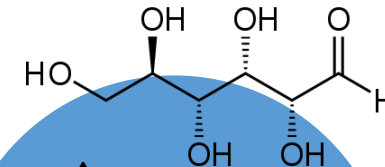
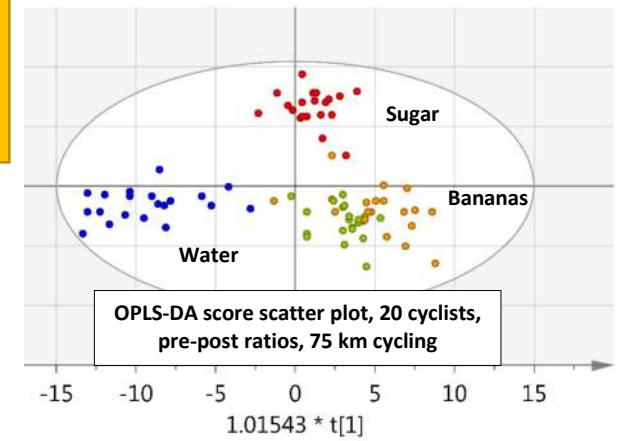
Fat oxidation and metabolite shifts

↓50%



Carbohydrate ingestion

METABOLOMICS  
Fruit polyphenols - oxidative capacity



↑ serum glucose, fructose, insulin

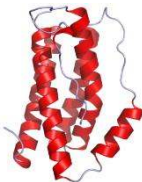
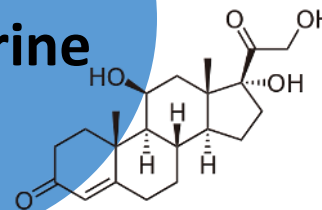
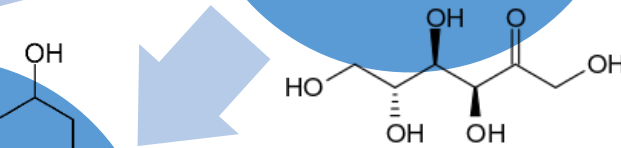
↑ performance (2-6%)

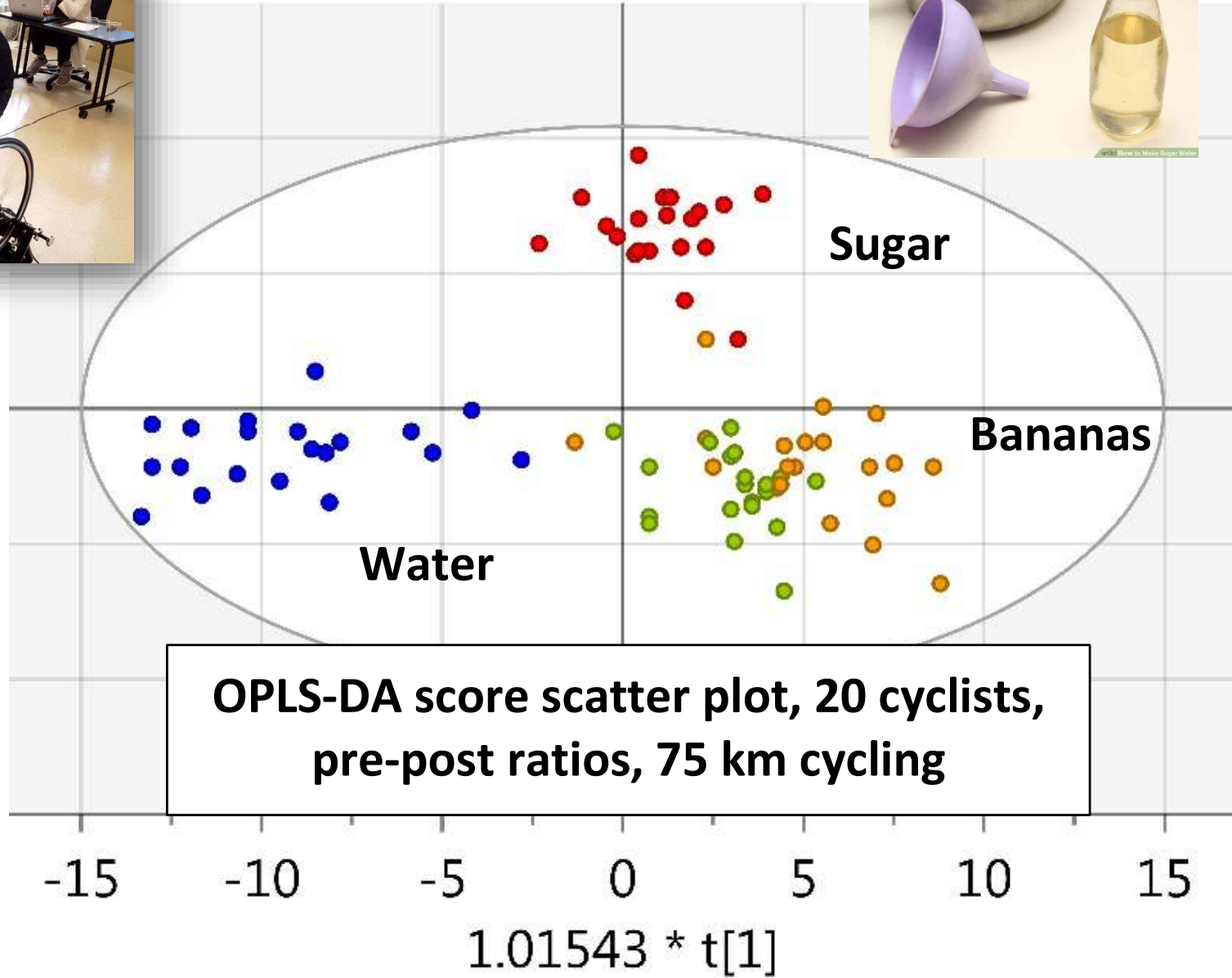
↓ inflammation

(reduced neutrophilia, monocytes, plasma IL-6, IL-1ra, IL-10, MCP-1; muscle IL-6, IL-8 mRNA)



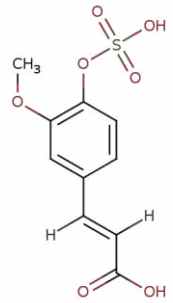
↓ cortisol, epinephrine





# Global Metabolomics

ferulic acid 4-sulfate

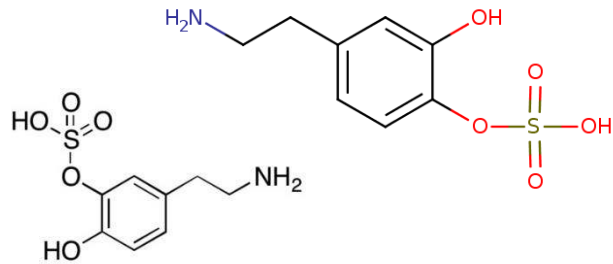


Pyridoxate  
(vitamin B6)

vanillic alcohol sulfate

2,3-dihydroxyisovalerate

dopamine 4-sulfate  
dopamine 3-O-sulfate



3-methoxytyramine sulfate

2-oxoarginine

4-imidazoleacetate



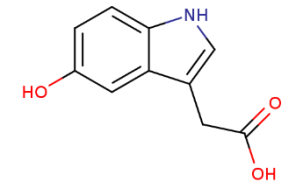
4-acetylphenol sulfate

caffeic acid sulfate

trigonelline (N'-methylnicotinate)

hydantoin-5-propionic acid

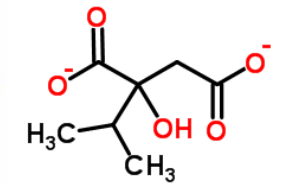
5-hydroxyindoleacetate  
(serotonin)



tyramine O-sulfate

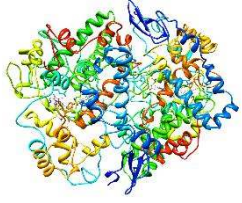
eugenol sulfate

2-isopropylmalate



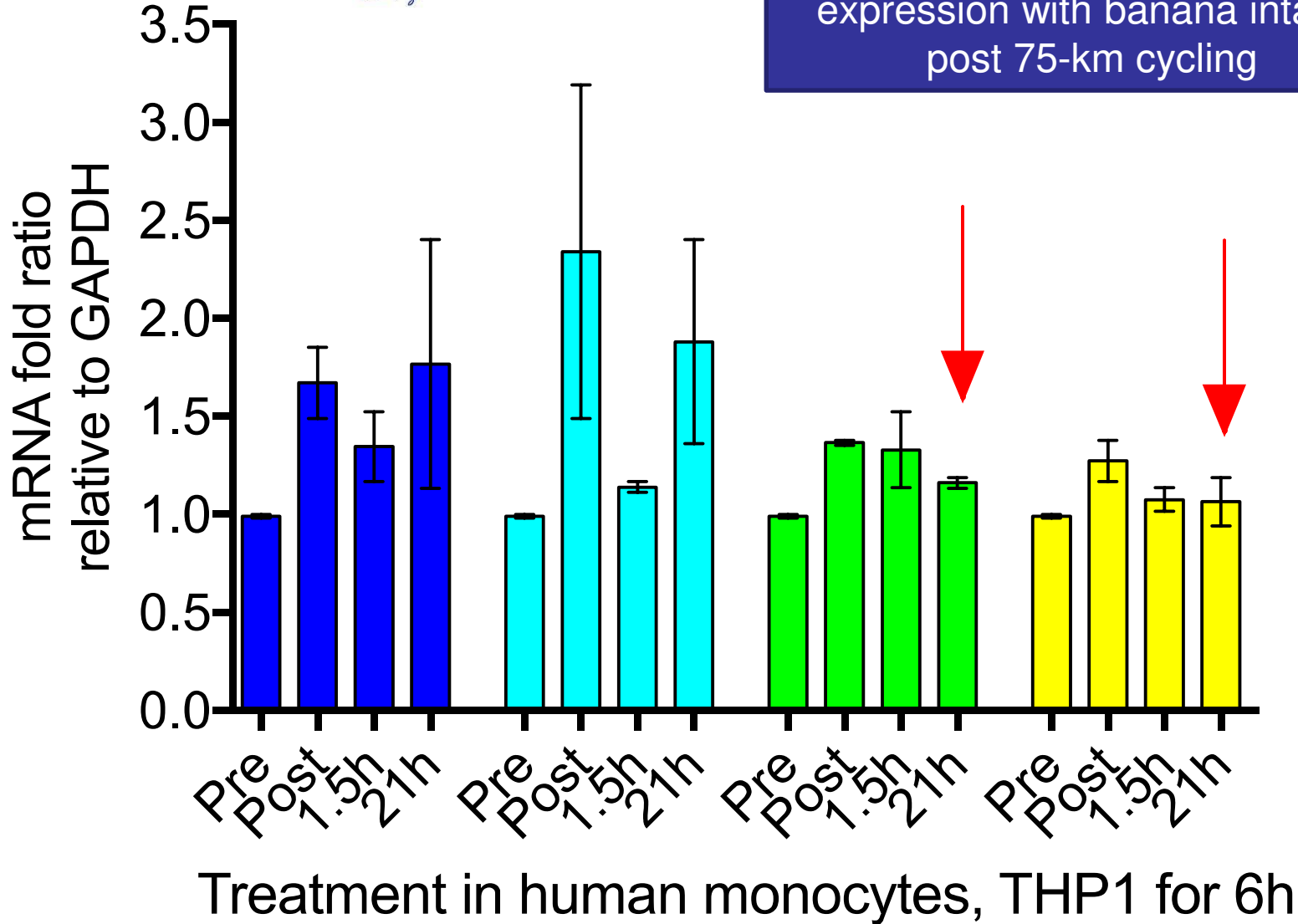
S-methylmethionine

# COX-2 mRNA



Nieman, Gillitt, et al. PLoS One, 2018, in press

Reduction in COX-2 mRNA expression with banana intake, post 75-km cycling



- Water
- Sugar water
- Cavendish
- Sports banana



# How COX-2 Inhibitors Work

**PAIN RELIEF:** 1 COX-2 is an enzyme that is activated at sites of injury. It manufactures hormone-like substances called prostaglandins, which trigger painful inflammation

2 COX-2 inhibitors are drugs designed to block the activity of the COX-2 enzyme and relieve pain



Banana carbohydrates supports performance, decreases inflammation and moderates physiological stress



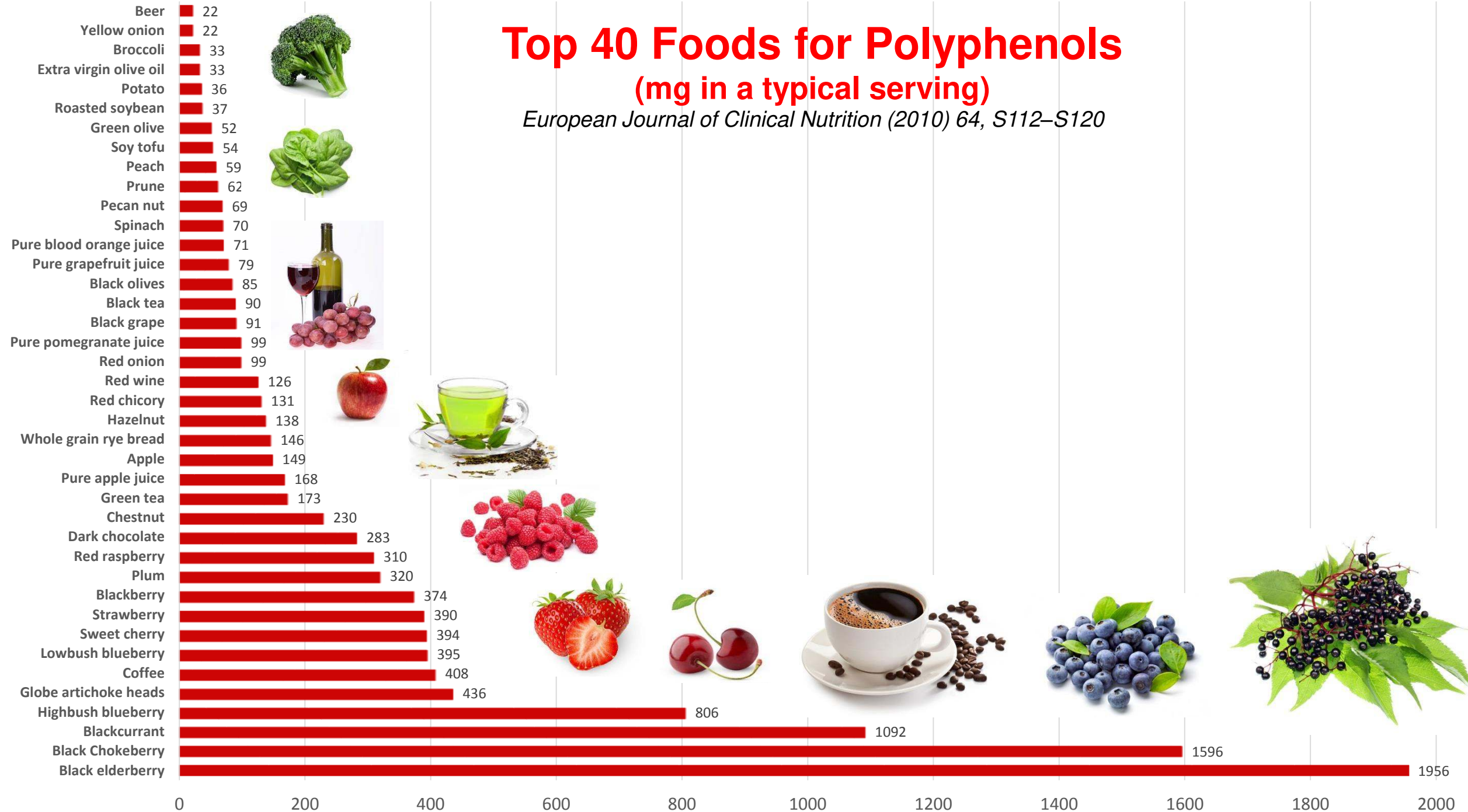
Banana metabolites after ingestion function similar to ibuprofen and aspirin



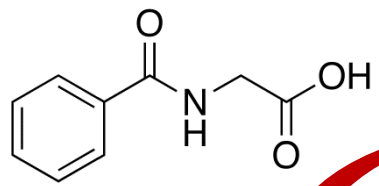
Nieman, Gillitt, et al. PLoS One, 2018, in press

# Top 40 Foods for Polyphenols (mg in a typical serving)

*European Journal of Clinical Nutrition (2010) 64, S112–S120*



# Polyphenol Metabolism



**Hippuric Acid**



1. Dietary polyphenol intake (majority to colon)

5. Released into circulation, exerts bioactive effects, and then eliminated in urine

4. Phase-2 conjugation

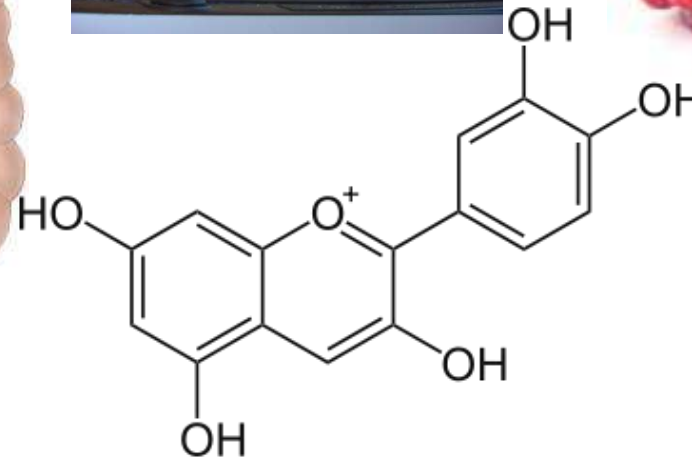
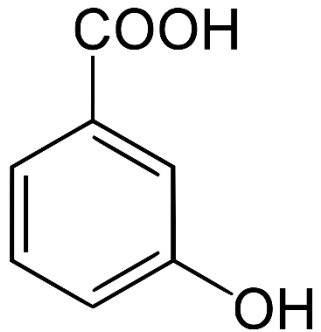
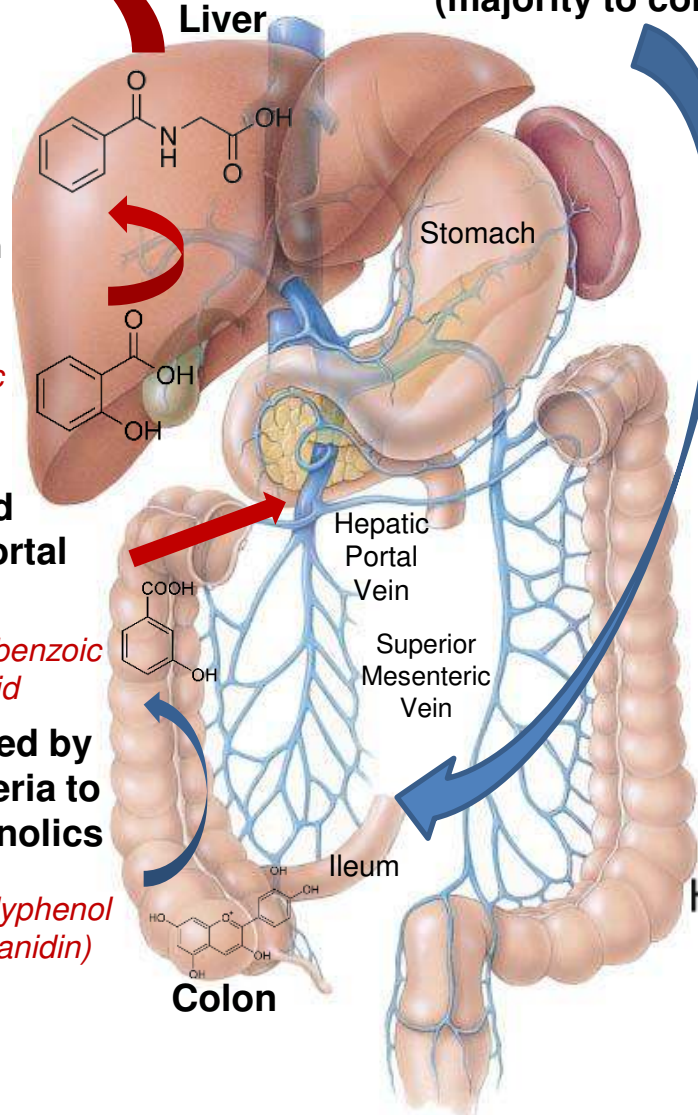
**Hydroxybenzoic Acid**

3. Absorbed and translocated via portal vein to liver

**Hydroxybenzoic Acid**

2. Converted by colon bacteria to simple phenolics

**Polyphenol (cyanidin)**

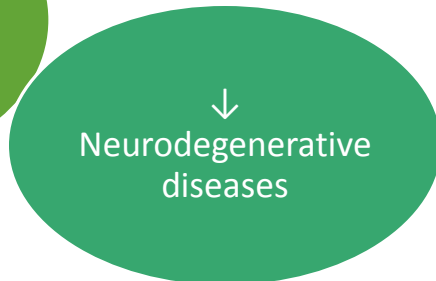
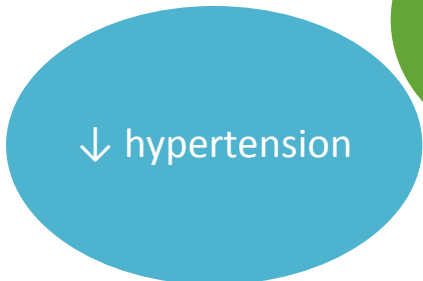






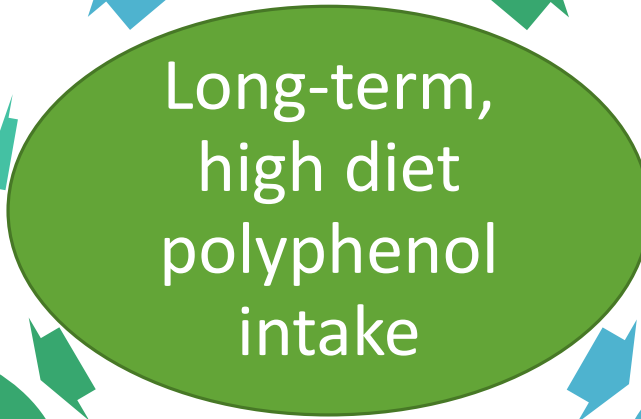
J. Nutr. **2013**, 143, 1445–1450

Am. J. Clin. Nutr. **2015**, 101, 1012–1020.



Am. J. Clin. Nutr. **2016**, 103, 1091–1098

Adv. Nutr. **2015**, 6, 64–72



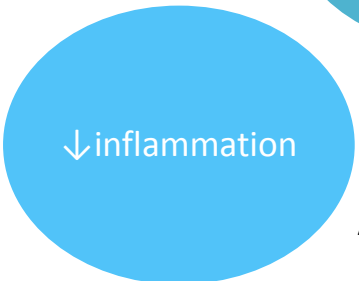
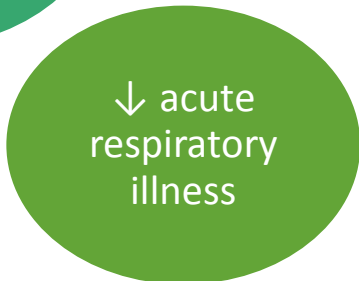
Br. J. Nutr. **2014**, 111, 1–11

BMJ **2016**, 352, 117–124.

J. Nutr. **2016**, 146, 767–777



Am. J. Clin. Nutr. **2014**, 99, 463–471



Adv. Nutr. **2016**, 7, 488–497

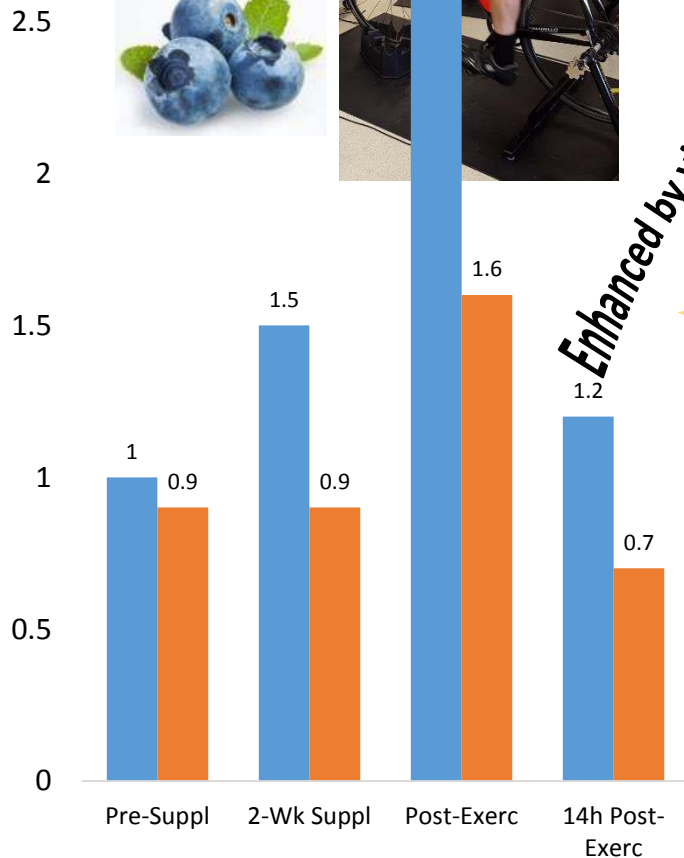
Am. J. Clin. Nutr. **2015**, 102, 172–181





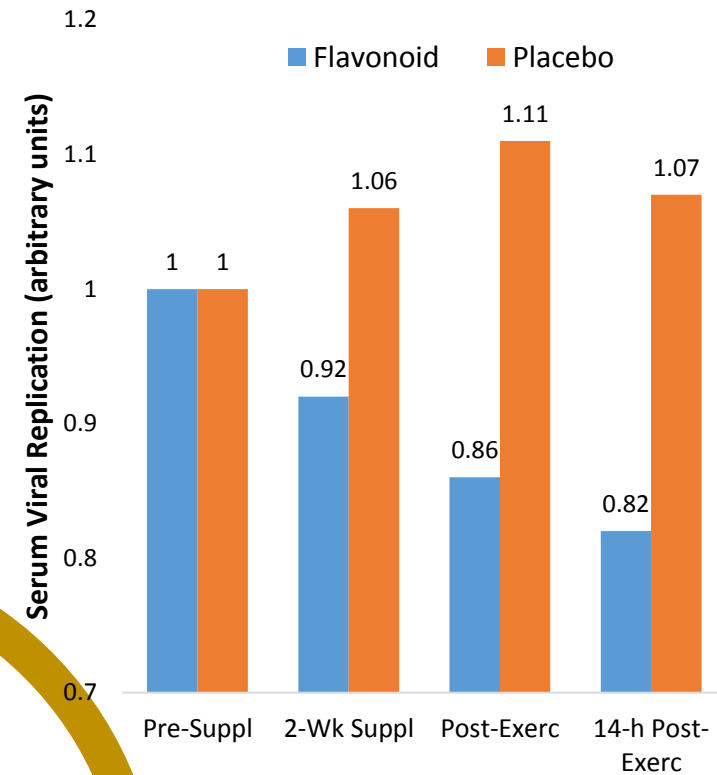
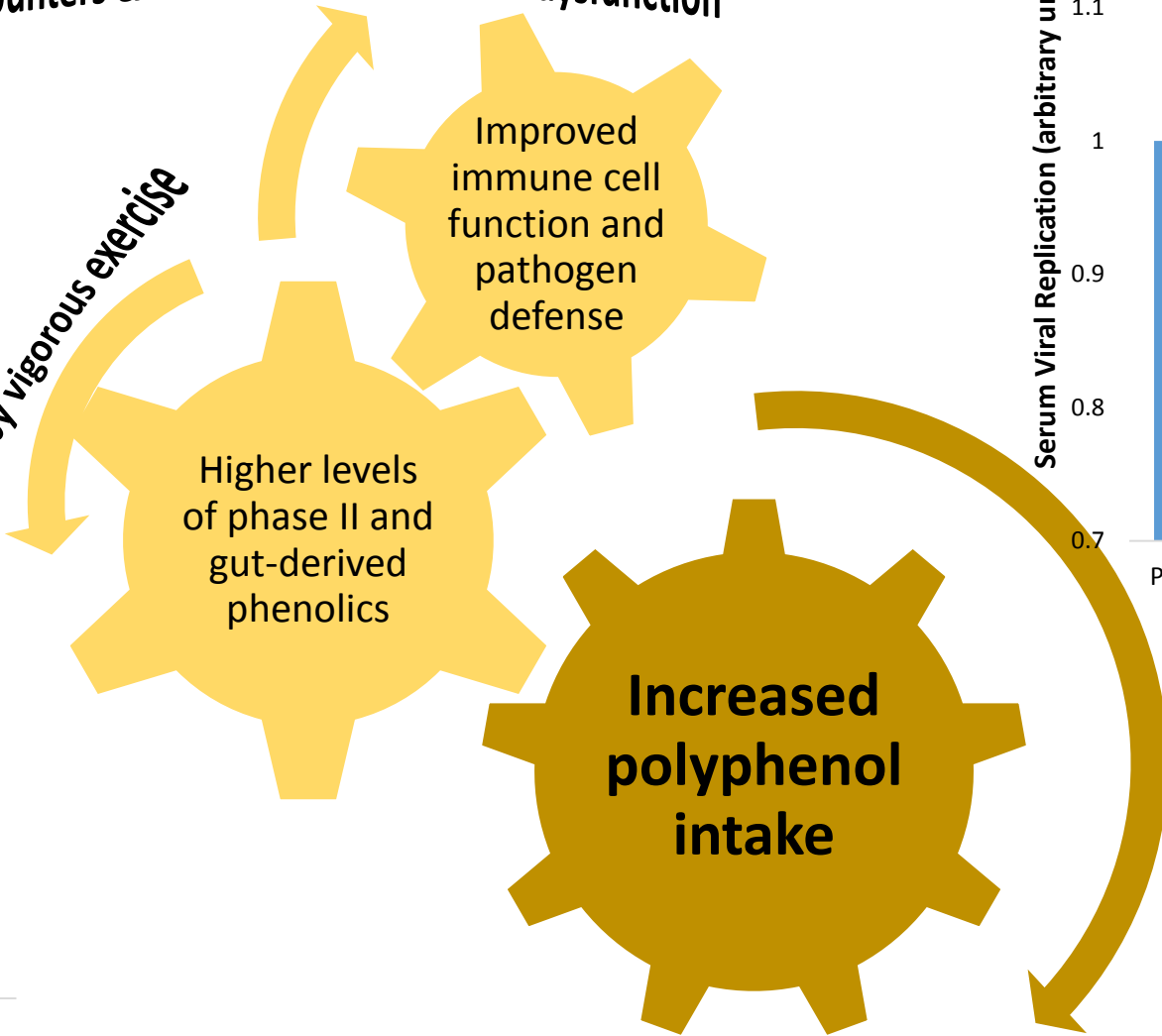
Counters exercise-induced immune dysfunction

Plasma Hippurate (MSI)

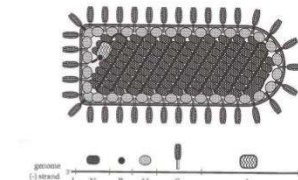
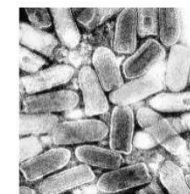


Flavonoid Placebo

Enhanced by vigorous exercise



Vesicular Stomatitis Virus (VSV)





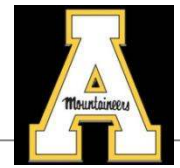
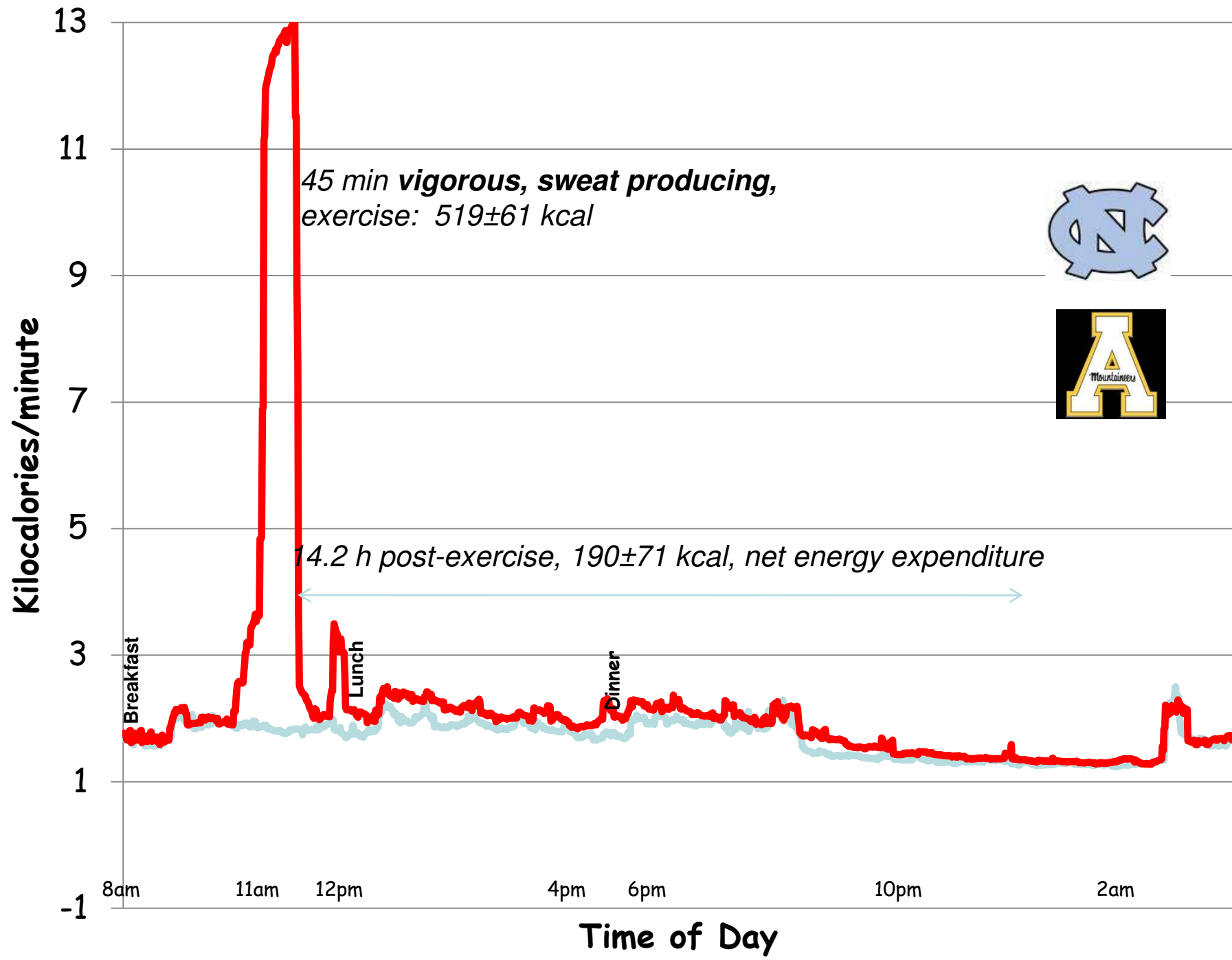
## UNC-Chapel Hill, Nutrition Research Institute, Metabolic Chamber

[A 45-Minute Vigorous Exercise Bout Increases Metabolic Rate for 14 Hours.](#)

Med Sci Sports Exerc. 2011 Sep;43(9):1643-8.







# ASU-North Carolina Research Campus Human Performance Lab



COLLEGE OF  
**Health Sciences**  
APPALACHIAN STATE UNIVERSITY

