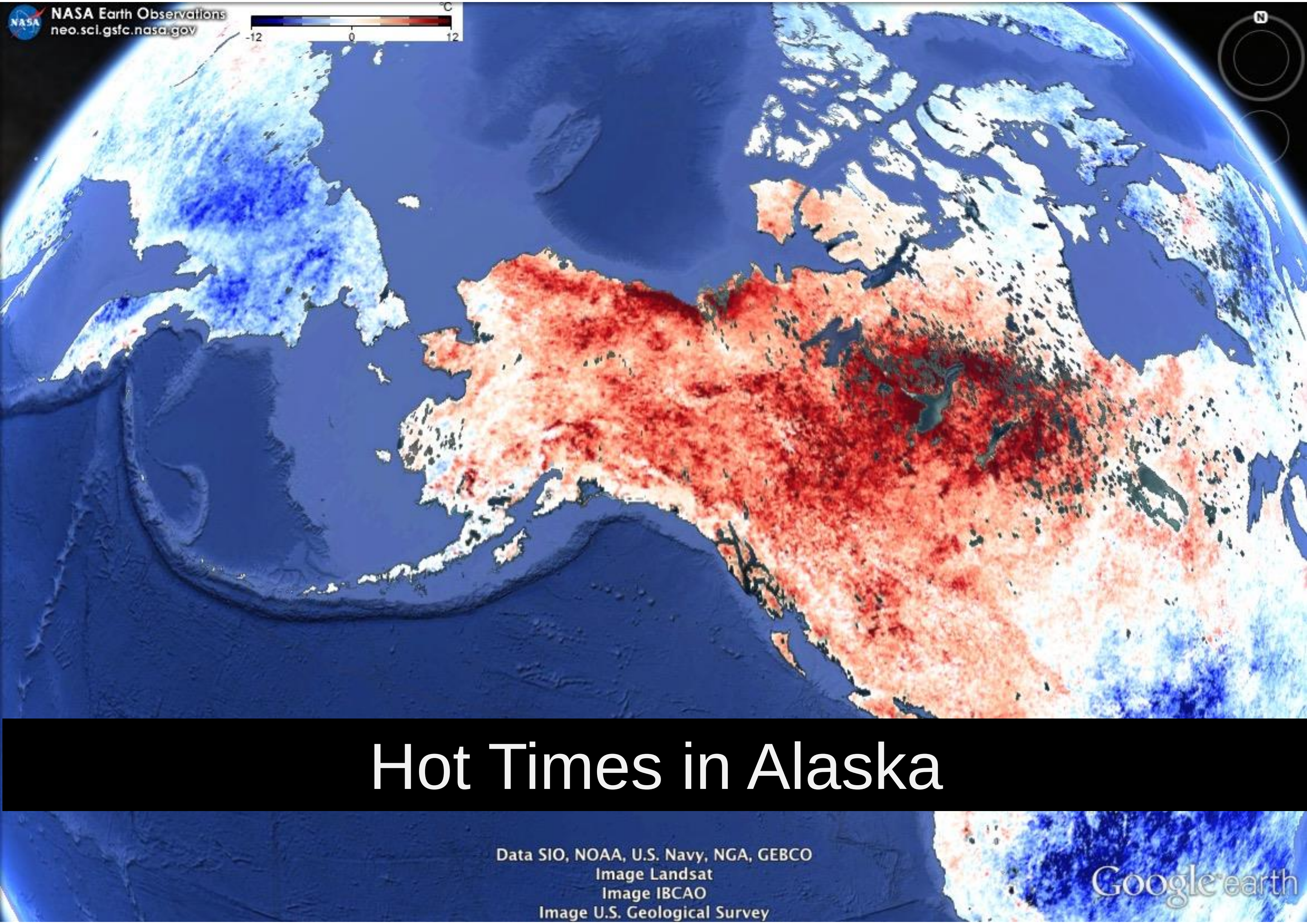
The Influence of Wildland Fire Operations on Adipose Tissue, Skeletal Muscle and Blood Lipids

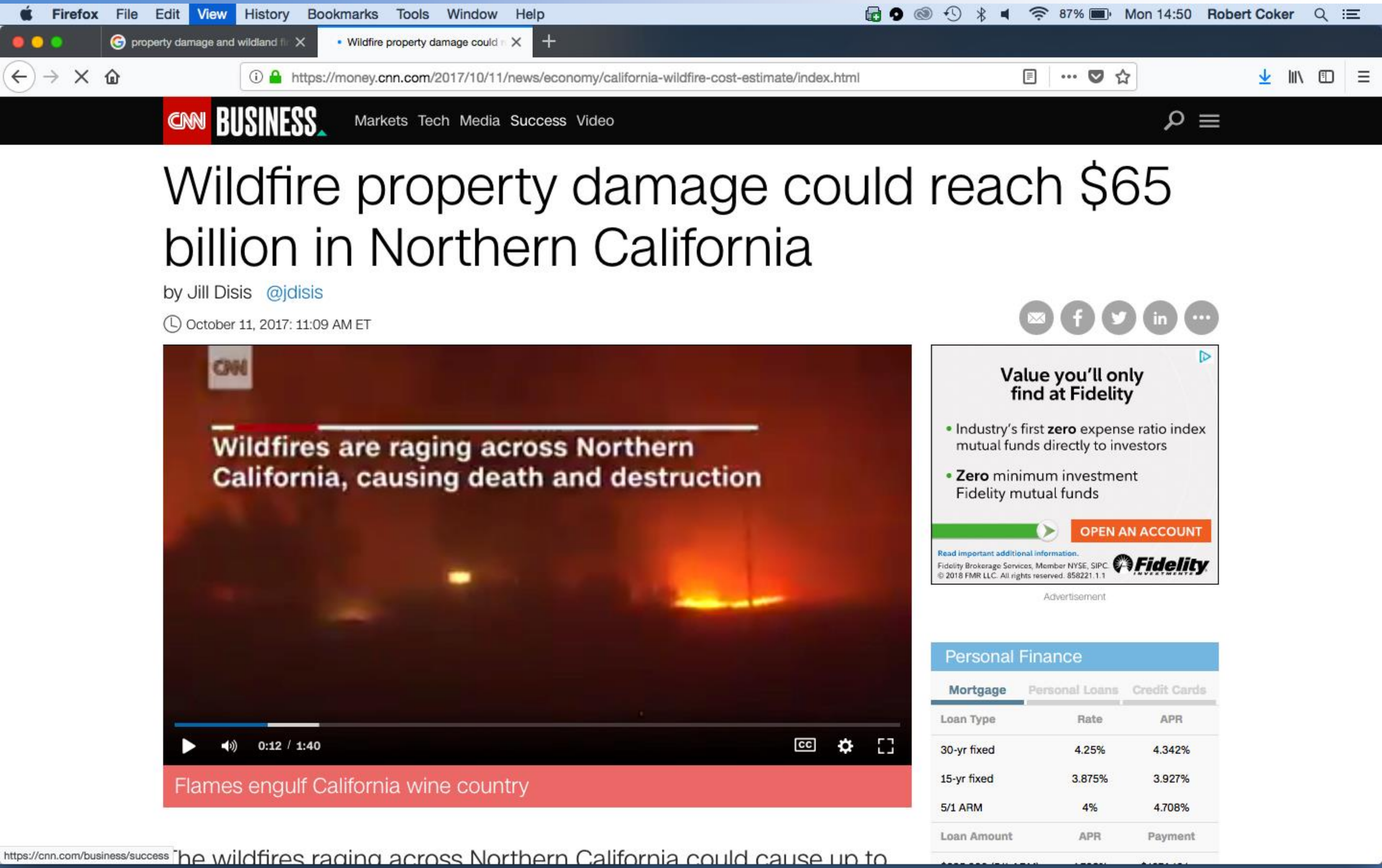
Robert Coker, PhD, FACSM, University of Alaska Fairbanks

Where I come from…?



Hot Times in Alaska

Attention focused on $$$$$

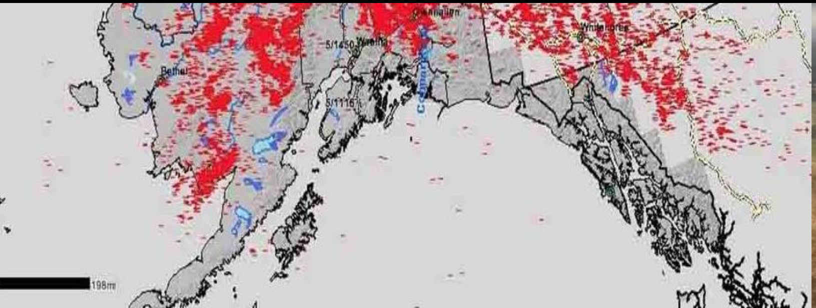


Danger to Civilians

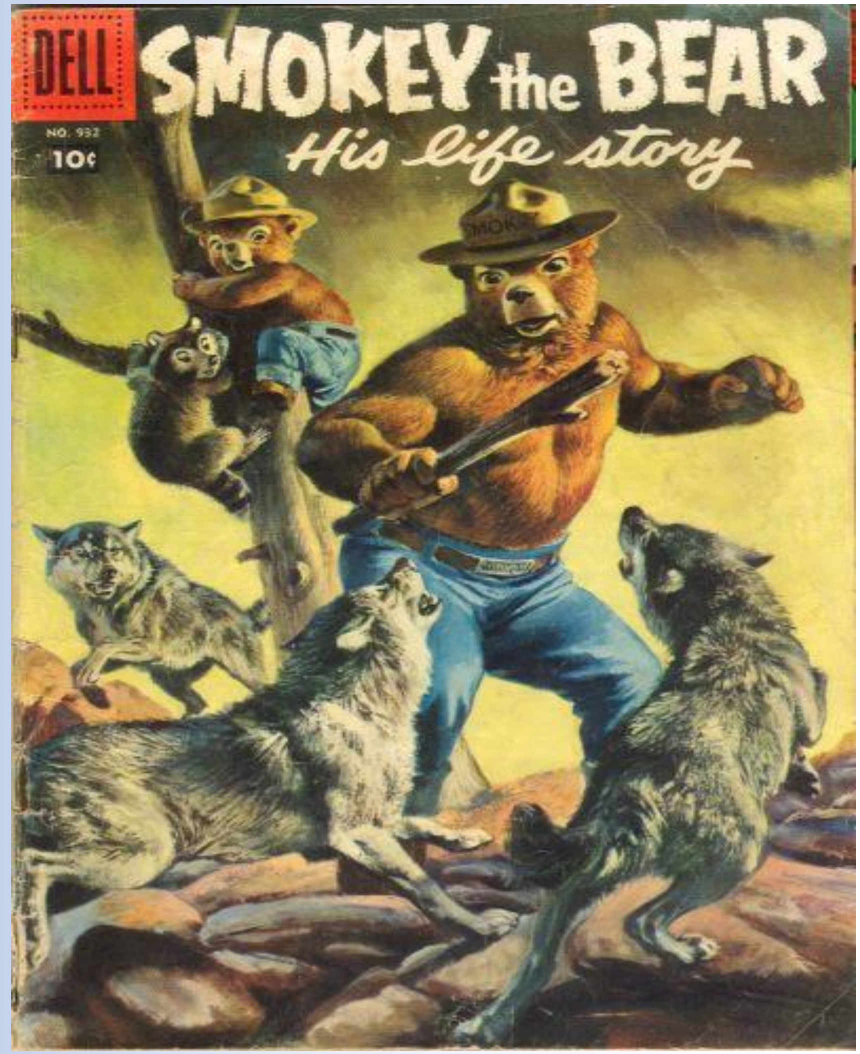
Threat to Infrastructure

73 Type 2 EFF crews
Many Alaska Native

What about occupational resilience and metabolic risk factors in Alaska Wildland Firefighters?



Tactical Ultra Enduro Power Athlete



According to Dr. Brian Sharkey in his book, "Fitness and Work Capacity - 2nd edition":

"*Our studies have shown that muscular fitness is highly related to performance of the tasks involved in wildland firefighting. Firefighters with more strength and muscular endurance are better able to carry the loads and use the tools than those with lower levels.*"

15 Year Comparison; Brent Ruby: UMT

4,182 kcals/day
(2719-6260 kcals/day)
(1.8-3.6 xBMR)

Total energy expenditure during arduous wildfire suppression

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Human Performance Laboratory, The University of Montana, Missoula, MT; and Nutritional Sciences, University of Wisconsin, Madison, WI

ABSTRACT

RUBY, B. C., T. C. SHRIVER, T. W. ZDERIC, B. J. SHARKEY, C. BURKS, and S. TYSK. Total energy expenditure during arduous wildfire suppression. *Med. Sci. Sports Exerc.*, Vol. 34, No. 6, pp. 1048–1054, 2002. **Purpose:** The purpose of this investigation was to determine the total energy expenditure (TEE) by using the doubly labeled water (DLW) methodology during 5 d of wildfire suppression in Montana, California, Florida, Washington, and Idaho. **Methods:** Seventeen wildland firefighters (from three Interagency Hot Shot crews, $N = 8$ men, height $= 177 \pm 7$ cm, weight $= 74.6 \pm 6.4$ kg, age $= 24.5 \pm 1.8$ yr; $N = 9$ women, height $= 170 \pm 7$ cm, weight $= 65.2 \pm 8.0$ kg, age $= 25.0 \pm 1.3$ yr) served as subjects. Before wildland fire suppression, each subject was given an oral dose of ^2H_2O and $H_2^{18}O$ (approximately 0.23 g $^2H_2O \cdot kg$ estimated TBW^{-1} and 0.39 g $H_2^{18}O \cdot kg$ estimated TBW^{-1}). Urine samples were collected between 0400 and 0600 daily. TEE was calculated using the two-point method for days 1–3 and 1–5, with the TEE for days 4–5 calculated by extrapolation. Urine samples from other crew members not participating in the DLW protocol were collected at the same times and used to adjust calculations of isotopic elimination for background shifts. **Results:** TEE was 17.4 ± 3.7 and 17.5 ± 6.9 $MJ \cdot d^{-1}$ during days 1–3 and 4–5, respectively. The energy expenditure associated with physical activity (EEA) was 8.8 ± 3.0 and 8.9 ± 6.1 $MJ \cdot d^{-1}$ for days 1–3 and 4–5, respectively. **Conclusion:** The current data demonstrate consistently high daily energy expenditure in the wildland firefighter. These data also demonstrate that the doubly labeled water methodology is an appropriate methodology for the measure of TEE during unpredictable field operations if adjustments are made for changes in background enrichment and elevated water turnover. **Key Words:** DOUBLY LABELED WATER, OCCUPATIONAL PHYSIOLOGY, FIRE-FIGHTING, ENERGY BALANCE, ENERGY EXPENDITURE PERIODS

Previous research has shown that the doubly labeled water (DLW) methodology serves as the gold standard for the measurement of total energy expenditure (TEE) of free-living individuals (18,27). However, the methodology requires rigorous quality control in regard to isotope preparation, sample analyses, and the application and timing of the isotopic dose relative to the sample collection period (27). These issues and costs make the use of the doubly labeled water methodology more difficult during actual field operations where the measurement period is unpredictable and conditions may be hazardous. Several studies have used the DLW technique in the field, including military operations (3,6,7,9,10,11,14), mountainous/arctic expedition (15,22,28), multiple-stage bicycle racing (24), extended training (20,23), and space travel (12,21). In the last decade, the use of doubly labeled water for measurement of TEE has received notable acceptance. However, the majority of prior "field" research has been conducted on a previously determined schedule (scheduled training/expedition period) with an anticipated start and finish time for the experiment.

Past research in field settings has used DLW for measurement periods of 5–8 d (7,10,24) and 10–12 d (3,9,11,14). Because the precision of the calculated TEE is dependent on the elimination rates of both isotopes ($_2H$ and $_{18}O$), it is necessary for the measurement period to be long enough to accurately calculate the difference in the elimination of the ^2H and ^{18}O isotopes but not so long that the isotopic abundances return to near baseline. In the sedentary or recreationally active individual, this optimal period is between 4 and 16 d given the typical isotopic dose (approximately 0.12 $g \cdot kg^{-1}$ total body water for ^2H_2O and approximately 0.3 $g \cdot kg^{-1}$ total body water for $H_2^{18}O$), anticipated water turnover, and low to moderate rates of TEE. However, when the work environment is likely to result in unusually high rates of water turnover, coupled with an elevated TEE, the measurement period should be shortened significantly, and adjustments may be needed to the initial isotopic dose to accommodate the more rapid rates of elimination.

During the summer months in the western part of the United States, land management agencies (United States Forest Service, Bureau of Land Management, and State Forestry) are involved in wildland fire suppression efforts. Wildland fire suppression is a seasonal occupation requiring long hours of heavy work under adverse conditions (extended work shifts up to 24 h, high ambient heat, compromised dietary intake, smoke inhalation, acute altitude exposure, and sleep deprivation). The common wildland-firefighting tasks often include hiking, fire-line construction, chain-saw

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BRIEF REPORT

Work Patterns Dictate Energy Demands and Thermal Strain During Wildland Firefighting

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4,556 kcals/day
(2946-6083 kcals/day)
(1.7-3.5 xBMR)

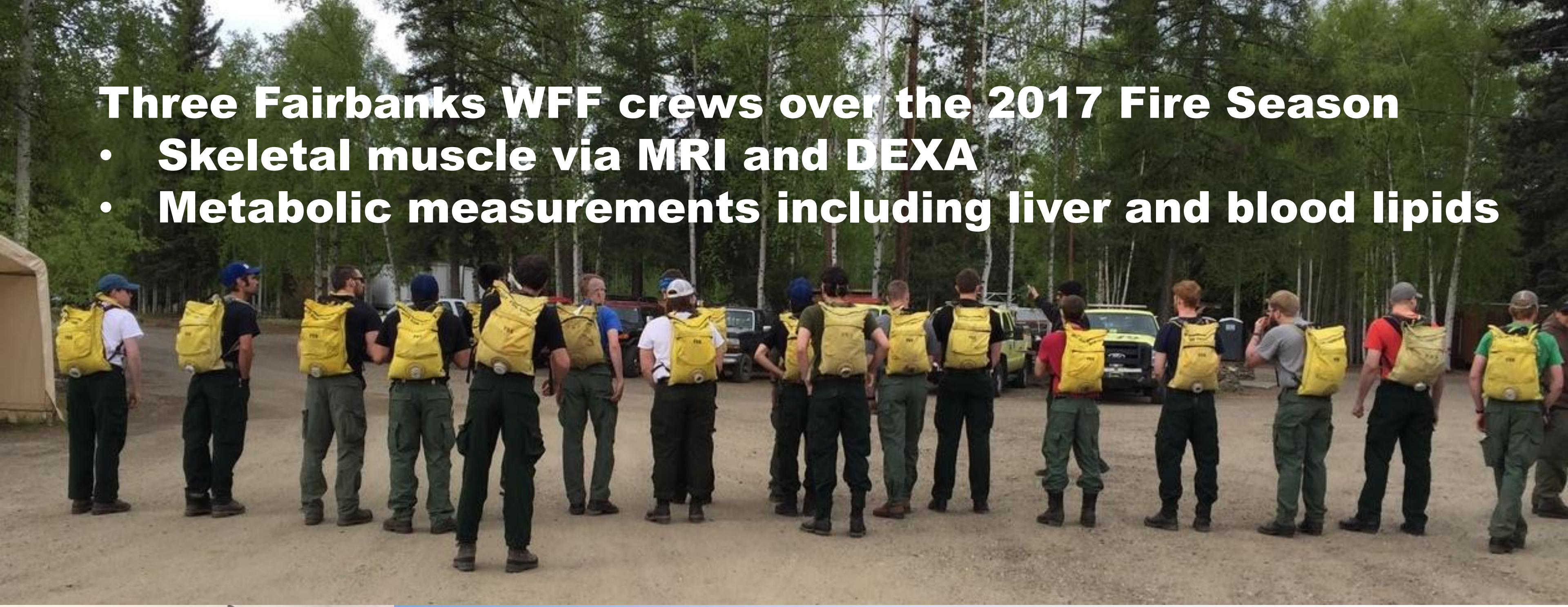
Stressors and Potential Consequences

- Energy expenditure
- Physical/Mental Fatigue
- Sleep deprivation
- Reduced appetite
- Environmental stress

- Loss of skeletal muscle
- Loss of bone density
- Increased injury/death

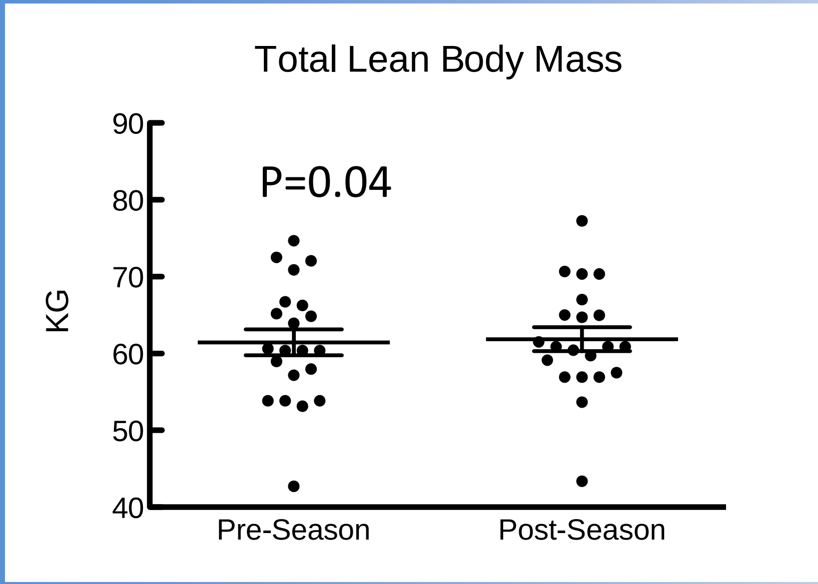
Three Fairbanks WFF crews over the 2017 Fire Season

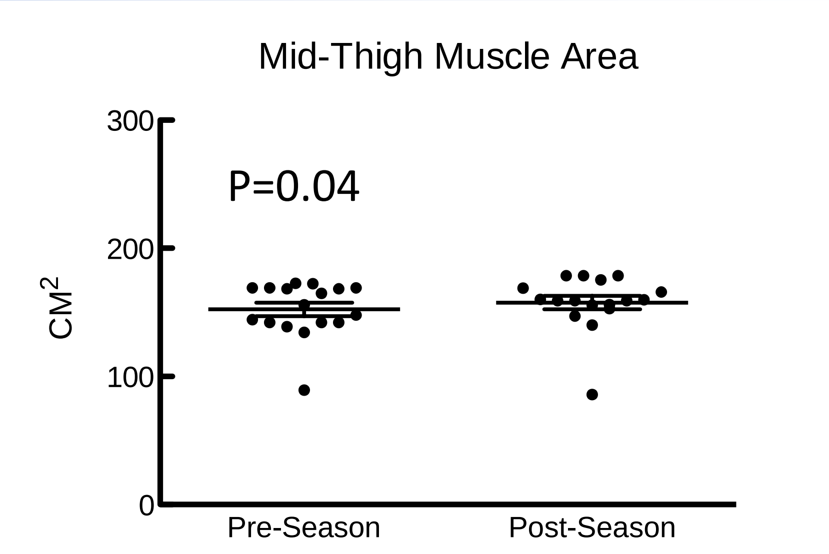
- **Skeletal muscle via MRI and DEXA**
- **Metabolic measurements including liver and blood lipids**

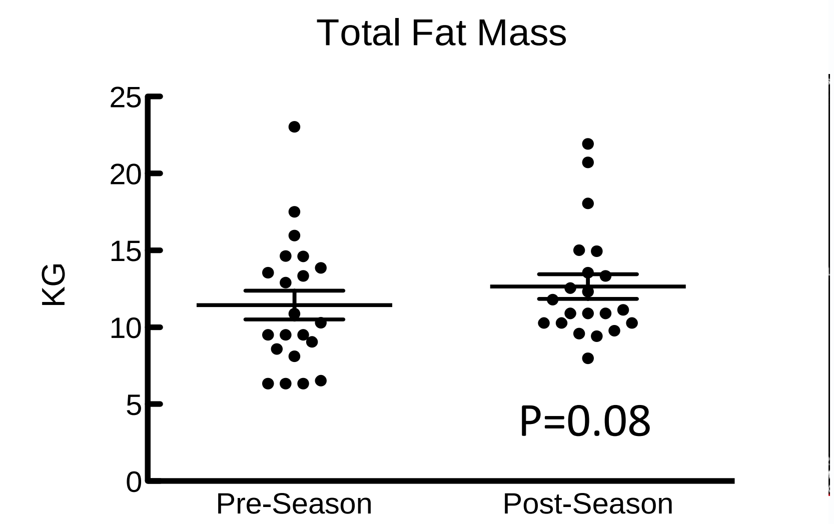


Do WFF's preserve their muscle over the season?

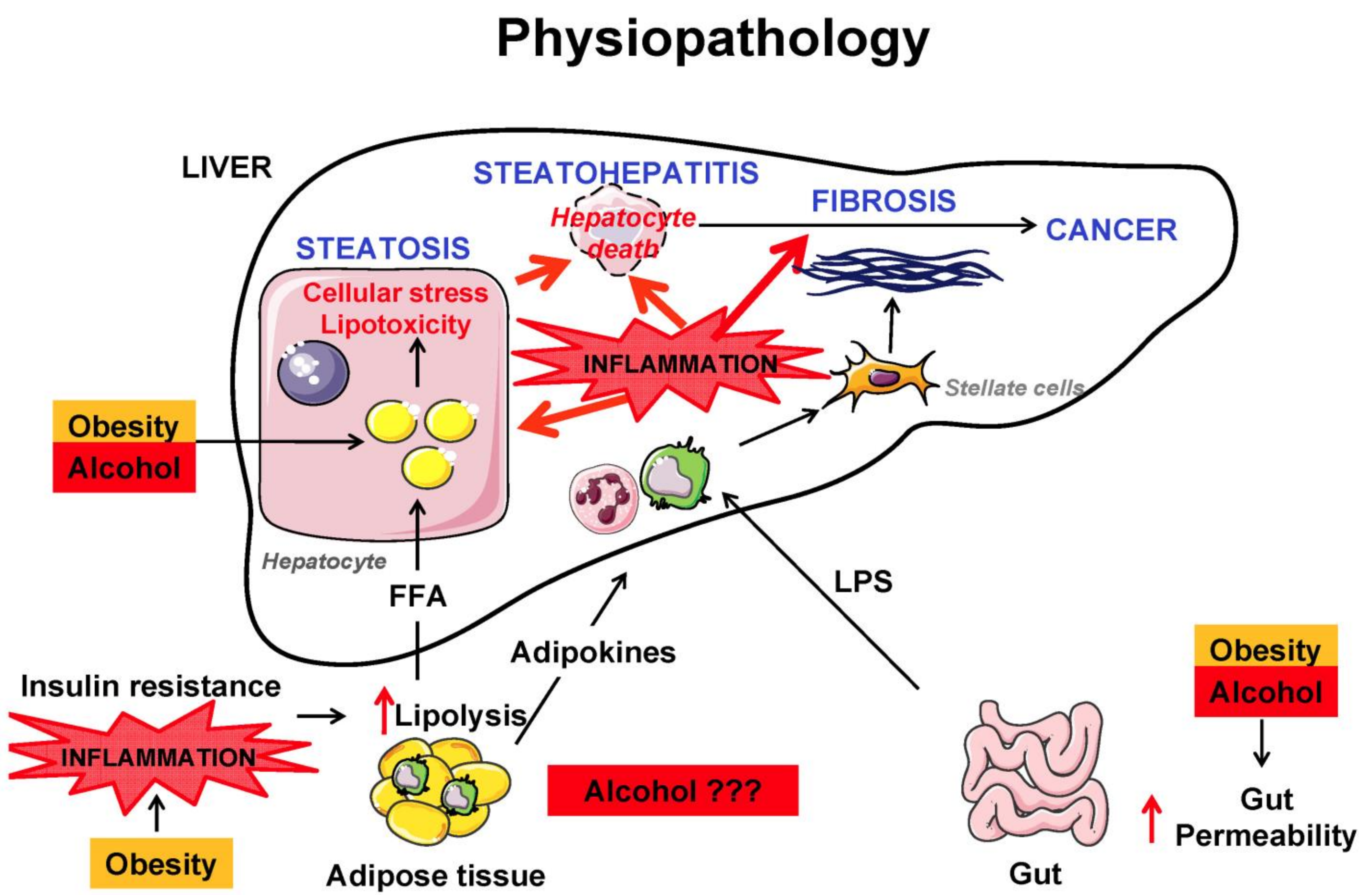
Surprisingly.. they maintain muscle



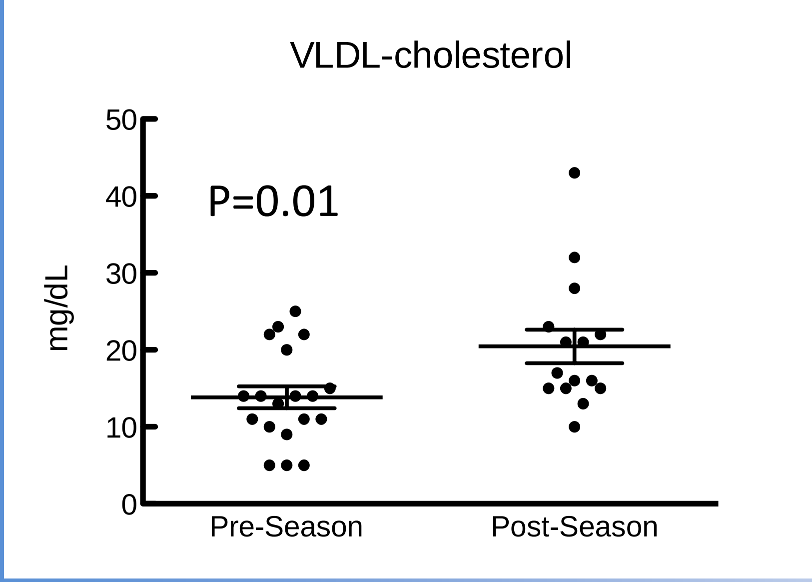


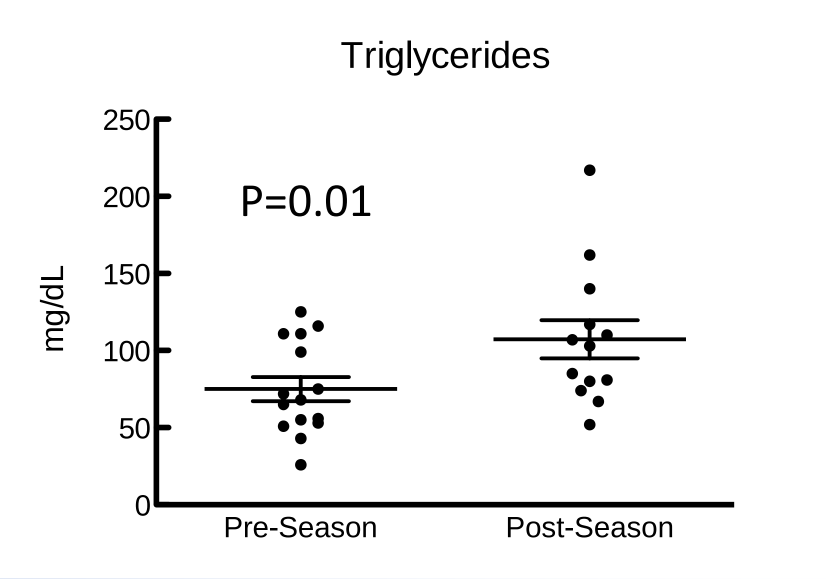


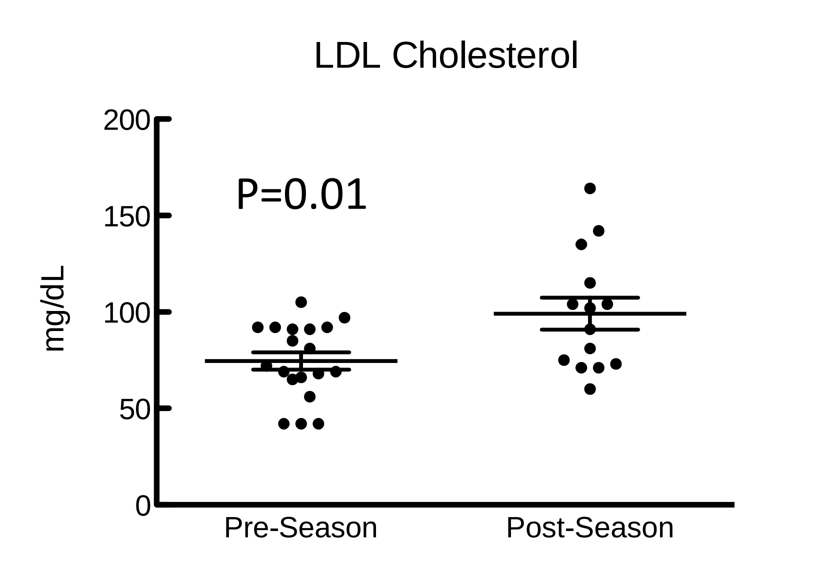
Increase in Intrahepatic Lipid

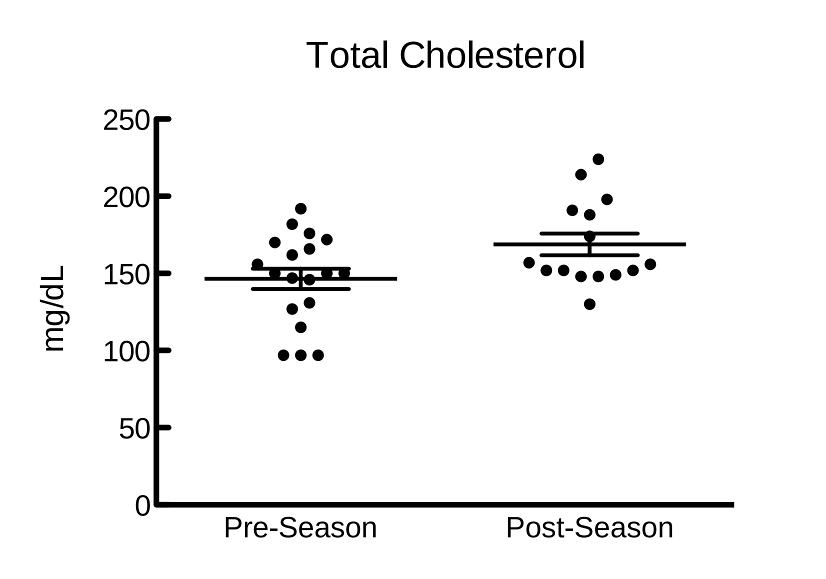


Connected to Increase in Blood Lipids









Metabolic Demands of Hiking in Wildland Firefighting, 2017

Table 3. Mean heart rate, core temperature, and predicted relative oxygen consumption values while hiking. Data are shown as mean ± STD.

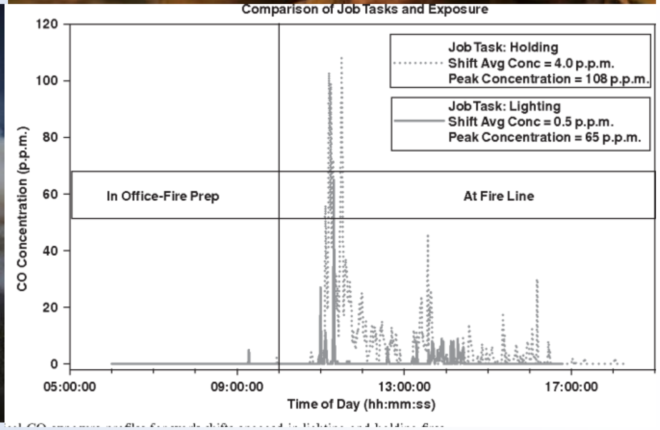
Hike Type	*Crew Type (# of min observed)*	*Heart Rate (bpm)*[c]	*Core Temperature (°C)*[ac]	*Oxygen Consumption – All Hiking (ml/kg/min)*	*Oxygen Consumption – Uphill Hiking Only*[b] *(ml/kg/min)*
Ingress	All *(n=1489)*	128 ± 29	37.5 ± 0.5	21.5 ± 12.3	25.8 ± 11.7
	IHC *(n=951)*	130 ± 28	37.5 ± 0.6	22.4 ± 12.0	26.7 ± 11.4
	Type II *(n=538)*	125 ± 30	37.4 ± 0.4	19.8 ± 12.2	24.1 ± 12.0
Shift	All *(n=2455)*	127 ± 23	37.7 ± 0.5†	19.1 ± 12.3†	22.9 ± 12.9†
	IHC *(n=1282)*	126 ± 24	37.6 ± 0.5	19.0 ± 12.0	23.1 ± 12.2
	Type II *(n=1173)*	129 ± 23	37.8 ± 0.5	19.2 ± 12.5	22.7 ± 13.5
Egress	All *(n=1217)*	120 ± 21†	37.6 ± 0.4†	19.0 ± 11.8†	25.3 ± 12.1
	IHC *(n=731)*	119 ± 23	37.6 ± 0.4	19.2 ± 11.3	24.6 ± 11.1
	Type II *(n=486)*	121 ± 19	37.8 ± 0.4	18.8 ± 12.4	26.4 ± 13.4
Training	All *(n=968)*	150 ± 27†	38.1 ± 0.9†	34.2 ± 14.5†	37.4 ± 12.5†
	IHC *(n=919)*	152 ± 26	38.1 ± 0.9	34.3 ± 14.4	37.6 ± 12.3
	Type II *(n=49)*	123 ± 35	37.2 ± 0.4	29.5 ± 15.3	30.4 ± 15.0

Pre-season training appears more aggressive?

Sol et al., Wilderness Environmental Medicine, 2017

Potential Causes

- Detraining effect
- Stress
- Diet
- Sleep Deprivation
- Smoke Exposure



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