

FITNESS, WORKRATES AND FATIGUE DURING ARDUOUS WILDFIRE SUPPRESSION

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GENERAL SUMMARY:

During the summer of 2001, 11 crew members from a Hotshot (Type 1) crew were followed for 9 days during which work rate was assessed via activity monitors and a submaximal HR index was collected mornings when possible. During the 9-day period the crew did a variety of work including initial attack. The crew was assessed for aerobic fitness and separated into “higher” and “lower” fit groups, though all firefighters would be considered ‘high fit’ on population normative tables.



The more fit wildland firefighters not only did more work (both absolute – 35% and corrected for body mass 17%), but that they recovered more quickly following periods of arduous work, especially during periods of extended high energy expenditure work shifts with limited rest. The more rapid physical recovery of the more fit crew members reduce their risk for upper respiratory tract infections and allows them to maintain a higher work rate on subsequent days.

The advantage of higher sustainable aerobic fitness was well documented by this study and suggests that physical training programs administered by wildland firefighting crews are beneficial in promoting a higher work output, improved recovery between work shifts and a decreased incidence or risk of upper respiratory track infections.

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Abstract

PURPOSE: The purpose of this study was to investigate work and recovery rates in wildland firefighters of differing levels of sustainable aerobic fitness. **METHODS:** Eleven (9M, 2F) wildland firefighters (WLFF) from one Interagency Hotshot crew served as subjects. Subjects were grouped by levels of sustainable aerobic fitness (SAF) as measured by VO_2 at the ventilatory threshold and studied in response to work rates and recovery after single or multiple arduous days of wildland fire suppression. Work shift energy expenditure (EE) was estimated using the method established by Heil (MSSE 33(5):s168, 2001). Recovery rates were measured using a submaximal HR step test index. **RESULTS:** * $p < 0.05$ between groups.

	SAF ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$)	EE $\text{Kcal} \cdot \text{day}^{-1}$	EE $\text{Kcal} \cdot \text{day}^{-1} \cdot \text{kg}^{-1}$	ΔHR Index 1 arduous day	ΔHR Index 3 arduous days
Low SF	34.6±3.5	2735±199*	39.7±3.8	5.1±18.0	37.3±14.7*
High SF	43.7±3.9	3425±354	44.6±2.1	10.6±18.7	16.1±21.0



CONCLUSIONS: Wildland firefighters with higher SAF (SAF range=40-49 $\text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$) are able to do more absolute and relative work during each day of a duty cycle compared to lower fit firefighters (SAF range=30-39 $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$). The more fit individuals recovered more quickly after multiple days of arduous work in spite of higher workloads. Since the lower fit group met or exceeded the minimal job specific fitness requirements for wildland firefighters as determined by the arduous pack test (SAF $\geq 23\text{-}25 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) these data suggest that the current fitness requirements may need review in that elevated sustainable fitness improves work output and recovery.

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INTRODUCTION

In a recent review of fitness and fatigue during arduous work several researchers have suggested that more fit individuals will not only perform work at higher rates, but might be less prone to symptoms of overtraining and fatigue and are better able to recover between daily work cycles (Gaskill, S.E., 2002-USFS-MTDC report).



Forest fire suppression involves arduous work (average = 7.5 kcal/min) for prolonged periods (12 to 24 hours) in difficult environmental conditions (heat, altitude, smoke).

There is a high incidence of upper respiratory tract infection (URTI) reported in wildland firefighters and it is the most common complaint during extended wildfire assignments. It is believed that the high incidence of URTI is due, in large part, to high levels of physical and emotional stress, dehydration, nutritional inadequacies and environmental conditions.

Participation and employment on most wildland firefighting crews requires that crew and supervisory personnel annually pass the "Pack Test." To pass the "Pack Test" individuals must be able to carry a 45 pound pack over a level 3 mile course in less than 45 minutes. The average energy expenditure during the pack test is about 23-25 ml•kg⁻¹•min⁻¹ and duplicates the average energy expenditure of about 7.5 kcal • min⁻¹ during wildland firefighting. However, it is not known if levels of fitness required to pass the "Pack Test" are adequate to reduce the incidence of URTI in wildland firefighters.

Since physical fitness is suggested as a method to enhance recovery following arduous work and to possibly reduce the incidence of URTI this research was undertaken to evaluate the effect of sustainable aerobic fitness (VO₂ at the ventilatory threshold) on both work output and recovery from arduous days of work.

METHODOLOGY

Wildland firefighters (WLFF) from one Interagency Hotshot crew in the Northern Rockies served as subjects (n=11, 9 males and 2 females). Subjects were grouped by levels of sustainable aerobic fitness (SAF) as measured by VO_2 at the ventilatory threshold and studied in response to work rates and recovery after single or multiple arduous days of wildland fire suppression. Work shift energy expenditure (EE) was estimated from CSA activity monitors using the method established by Heil (MSSE 33(5):s168, 2001).

Recovery rates were measured using a submaximal HR Step Test Index administered 05:30 (5:30 am) and post shift normally about 18:30 (6:30pm). The HR Step Test Index is determined using the sum of three heart rates:

- Resting Heart Rate after sitting quietly for 5 minutes.
- Exercise Heart Rate after bench stepping (20.3cm [8inch] step, 40 cycles•minute⁻¹) for 1 minute.
- 30 second recovery Heart Rate after sitting for 30 seconds post stepping.



RESULTS:

Figure 1 shows the absolute daily energy expenditure of the crew members participating in the study separated into higher and lower fit groups. Fitness levels in both groups well exceeded the standard required by the pack test. Note that on the higher intensity work days (days 3, 4, 6, 7, 8 and 9) and for the overall average the higher fit group did significantly more work per day. Work was estimated using CSA activity monitors which measure body displacement and Kcal were estimated from the CSA data using equations developed by Dan Heil (MSSE 33(5):s168, 2001). This figure does not take into account body size, using only absolute VO_{2vt} (liters/min) and total kcal of energy expenditure per day. On average, the more fit members of the crew did 29% more work on a daily basis or the equivalent of nearly 3.5 hours more work during a 12 hour day. Significant ($p < 0.05$) daily differences are noted by the “*”.

FIGURE 1: Daily Energy Expenditure(Kcals) and VT(L/min)

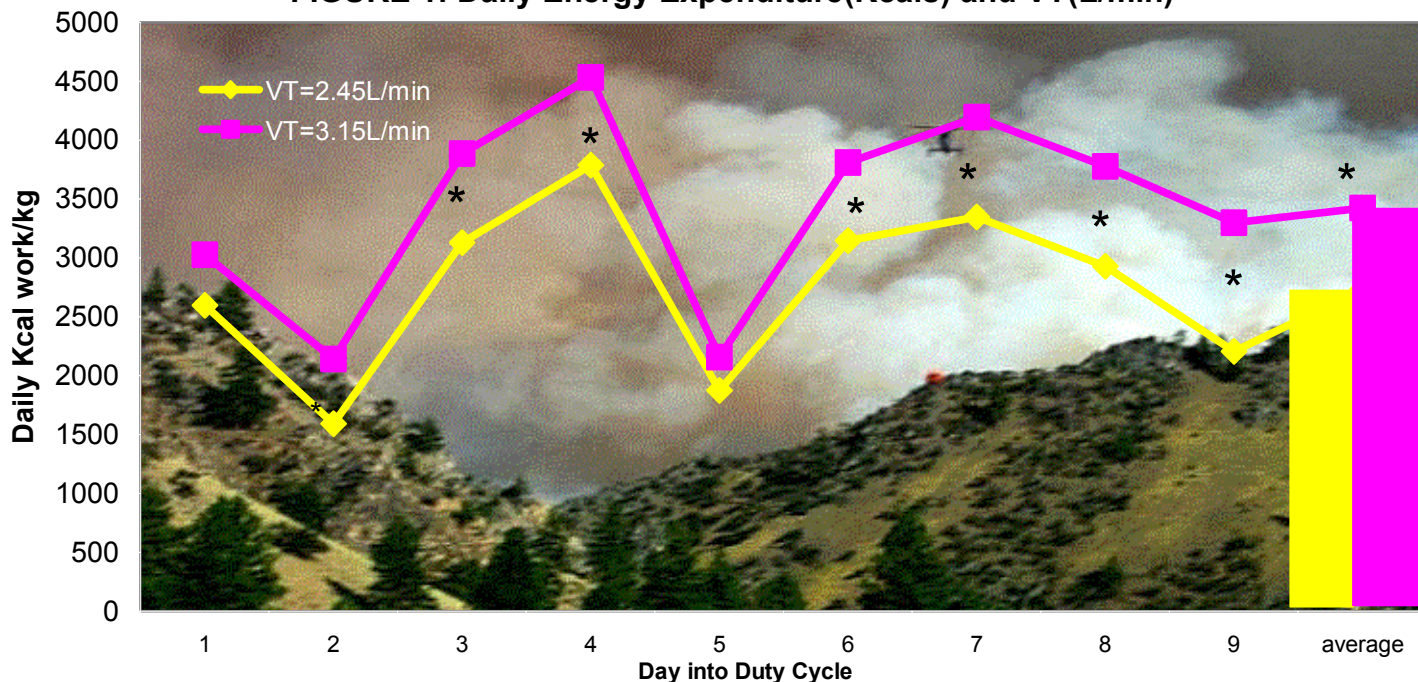




Figure 2 shows the same data as Figure 1, but the data are adjusted for body weight. The same pattern of results is again evident. Even after adjusting for body mass, on the higher intensity work days (days 3, 4, 6, 7, 8 and 9) and for the overall average, the higher fit group did significantly more work per day. However, once weight is accounted for the higher fit group averaged on 17% more work per day per kg of body weight resulting in the equivalent about 2 hours more work in a 12 hour work shift than the less fit individuals. Significant ($p < 0.05$) daily differences are noted by the “*”.

FIGURE 2: Daily Energy Expenditure/kg and VT(ml/kg/min)

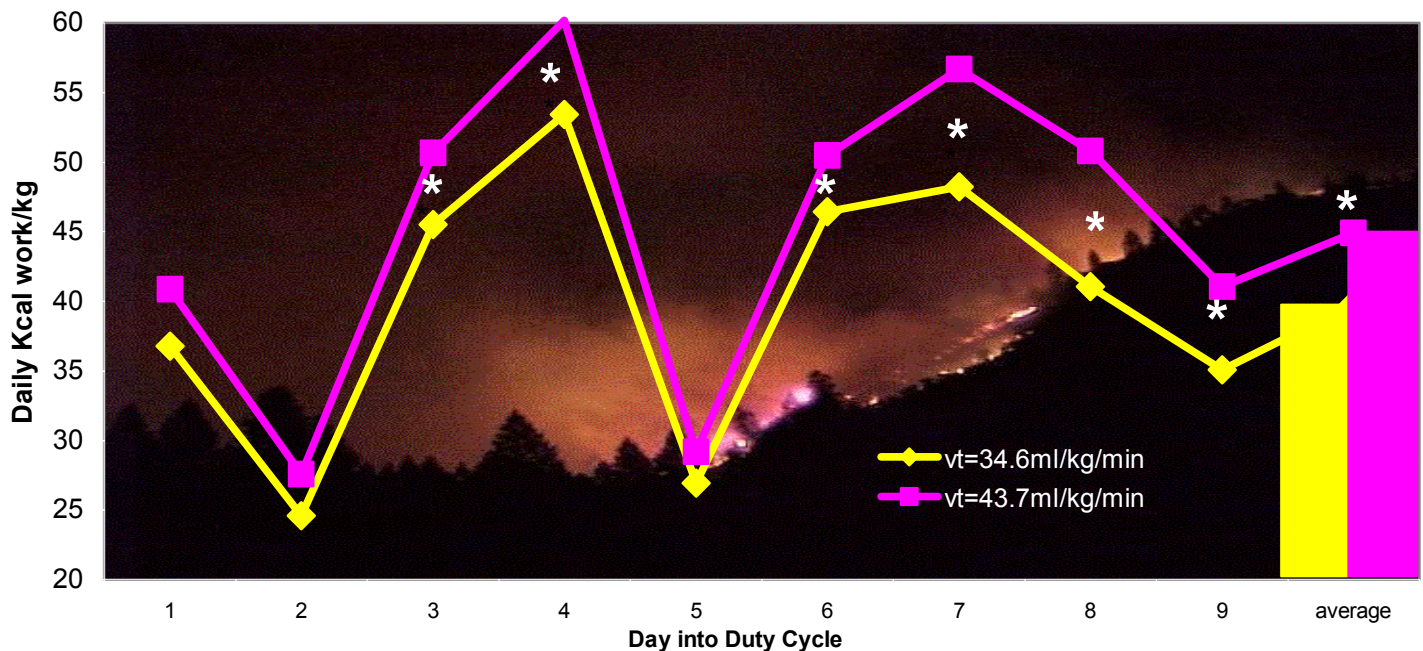


Figure 3 shows the complex relationship between daily work (energy expenditure of activity in kcal) shown by the light blue bars and increases in the HR index (resting + exercise = recovery heart rate values) between the more fit firefighters (violet line) and lower fit group (yellow line). The heart rate index was not collected each day as the fire crew was in a spike camp (self supported inaccessible camp), but activity monitors were worn throughout the period allowing for the estimation of total energy expenditure on a daily basis. Within the large red circle not that there were five days out of six where energy expenditure of activity was very high (> 3,800 kcal/day). The step HR index test administered on the morning of day six, following lower intensity activity during day five (1,800 kcal energy expenditure of activity) showed only a slightly elevated HR index in both groups (lower and higher fitness) suggesting that the crew had recovered overnight. However, following days 6, 7 and 8 of high intensity work, both groups demonstrated high HR indices on the 9th morning showing a lack of recovery. Day 9 was a day of moderate activity energy expenditure (2850 kcal). The following morning the more fit group had nearly recovered to baseline levels on the HR index while the lower fit group appeared to remain fatigued. Salivary IgA verified these HR data and showed significantly depressed levels of salivary IgA in the lower fit group on morning 10.

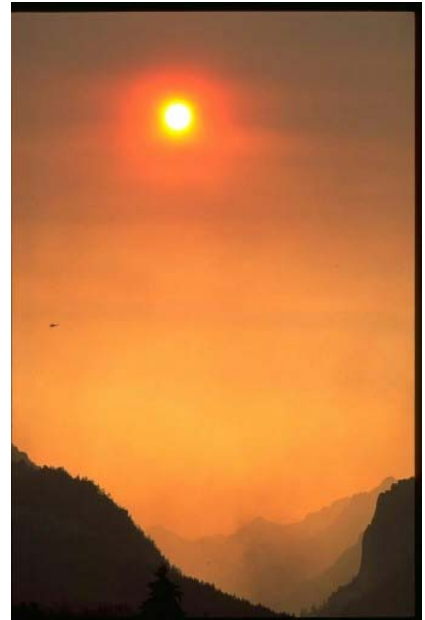
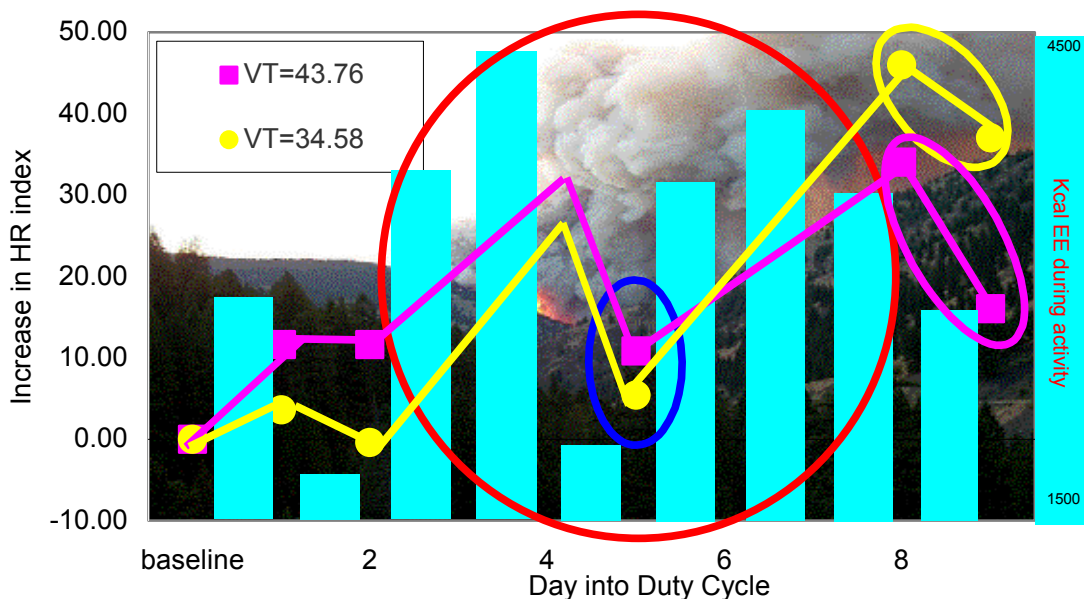


FIGURE 3: Change in HR index grouped by VT(ml/kg/min)



SUMMARY AND DISCUSSION:

Ruby, et al. has previously shown that the HR index is inversely related to Salivary IgA in wildland firefighters (Ruby, MSSE, 2002).

These HR and energy expenditure data show that more fit wildland firefighters not only do more work (both absolute and corrected for body mass), but that they recover more quickly following periods of arduous work, especially during periods of extended high energy expenditure days with limited rest.

The more rapid physical recovery of the more fit crew members reduces their risk for upper respiratory tract infections and allows them to maintain a higher work rate on subsequent days.

While crew members were separated into those who had higher levels of sustainable fitness and those with lower levels, all members would be considered highly fit compared to the average U.S. population and all had fitness levels well above those required for the arduous pack test.

The advantage of higher sustainable aerobic fitness was well documented by this study and suggests that physical training programs administered by wildland firefighting crews are beneficial in promoting a higher work output, improved recovery between work shifts and a decreased incidence or risk of upper respiratory track infections.



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