Carbohydrate Feedings Increase Self-Selected Work Rates During Arduous Wildfire Suppression

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General Summary

During the 2002 fire season two Type 1 Hotshot crews were evaluated during 12-hour shifts for work output and blood glucose when each hours they were fed either a placebo drink or a solution containing about 160 calories of carbohydrate. Crewmembers all ate a normal breakfast, the lunch supplied and normal dinner. Crewmembers, using automated blood glucose monitors, measured their glucose levels each hour using a finger prick. Additionally, they wore activity monitors that measure movement and work rate. The purpose of the study was to evaluate the effect of supplemental carbohydrates on blood glucose (which is related to poor decision making when low) and work output.

Biscuit Fire, Oregon, 2002

When wildland firefighters eat 40 grams (160 calories) of carbohydrate each hour during extended shifts there is maintenance of blood glucose and work output when compared to eating breakfast, lunch and dinner only but not supplementing carbohydrate intake during the work shift.

The decreases in blood glucose and work output were evident in the two-hour period before lunch and during the final four hours of a 12-hour workday. The decrease in blood glucose could also have serious implications for cognitive decision-making and safety, especially since the decreased blood glucose was most serious late in the afternoon when fire behavior is likely to be most severe.

The increased work output when supplementing with 160 calories each hour was the equivalent of an extra 1.75 hours of work each day and suggests that for a minimal cost, self-selected work rate will be maintained at a higher level resulting in more effective fire suppression.

A summary of the scientific report begins on the following page.

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Abstract

Our laboratory has demonstrated that the total energy expenditure of extended wildfire suppression may exceed 26 MJ·d^{-1} (MSSE 34(6):1048-54, 2002). Moreover, the majority of the total daily energy intake is provided before and after the extended workshift and supplemented with a mid-day sack lunch. PURPOSE: To determine the effects of supplemental carbohydrate (CHO) feedings on self-selected work rates during extended arduous wildfire suppression. METHODS: Subjects included wildland firefighters (N=20 Hotshots) during two wildfires in ID and OR. Subjects consumed a CHO (200 ml·hr^{-1}, 20% maltodextrin (40g·hr^{-1})) or placebo (PLA) drink in a counter-balanced crossover design and were allowed ad lib water intake during the day. Blood samples were collected at two-hour intervals with automated glucometers. Self-selected hourly work rate was determined using CSA accelerometer count data. Data were analyzed using a priori planned comparisons across trials. RESULTS: During the 20% CHO trials, blood glucose (mM) was significantly higher ($p<0.05$) immediately prior to lunch (CHO=5.9±1, PLA=5.4±0.9) and at four (CHO=6.7±1.1, PLA =5.6±.8) and six hours (CHO=6.2±1.0, PLA=5.0±0.6) post lunch, and immediately post shift (CHO=5.8±1.3, PLA=4.7±0.6). Self-selected work rate was similar across trails during the initial hours post breakfast but were significantly different later in the morning (mean 4-6 hour post breakfast: CHO=58,088±15,730, PLA=40,191±20,070 counts·hr^{-1}). Work rate was also similar across trials during the early hours after lunch but was significantly different later in the afternoon (mean 4-6 hour post lunch: CHO=64,172±30,501, PLA=47,528±26,541 counts·hr^{-1}). CONCLUSIONS: Self-selected work rate is higher during arduous wildfire suppression when CHO is delivered at a rate of 40 g·hr^{-1} (200 ml·hr^{-1}, 20% solution).

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Introduction

Recently our laboratory has demonstrated that the TEE associated with wildfire suppression may exceed 6000 kcal/day (26.4 MJ/day) resulting from consistent work outputs and extended work shifts (Ruby et. al, MSSE 34(6):1048-54, 2002). 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).

The job routinely includes packing heavy loads, building fireline with hand tools, and emergency responses, often under arduous and dangerous field conditions. Firefighters perform their duties while wearing personal protective gear that balances the needs for protection, performance, and mobility. In busy fire seasons, firefighters may work as many as 21 days without relief, with meals provided by field rations, a remote fire camp, or an organized camp with full field kitchen. When combined with pre and post-season work on prescribed fires, firefighters may log over 100 days of work in a season and over 1000 hours of overtime.

Although carbohydrate feedings have become commonplace during endurance exercise and have consistently demonstrated an ability to enhance performance, there is limited data available during extended arduous periods of work. This is especially true for situations that represent “un-simulated” work in an unpredictable and potentially hostile environment.

Purpose

The purpose of this study was to evaluate the effects of supplemental liquid carbohydrate (CHO) feedings on the maintenance of blood glucose and self-selected work rates during extended arduous wildfire suppression.

The wildland firefighter is continuously exposed to arduous, hostile work that incorporates extreme physiological and psychological stress in a combat like setting.

Methodology

Subjects included wildland firefighters (N=20) recruited from two hot shot crews in the northern Rockies. Subjects were studied during one of two wildfires (Kelly Creek Fire - Riggins, Idaho, Bisquit Fire - Western Oregon).

Subjects were studied during two work shifts (12 hours) using a randomized counterbalanced repeated measures design and were provided with either a CHO or placebo during the entire work shift. CHO included hourly ingestion of a flavored maltodextrin solution (200 $ml \cdot hr^{-1}$ of a 20% solution for a total of 40 $g \cdot hr^{-1}$). Placebo included a similarly flavored solution ingested at the same volume and hourly intervals.

Blood glucose samples were collected prior to and every two hours during the 12 hour work shift using a One Touch Ultra automated glucometer (LifeScan, inc.). Subjects were issued their own glucometer and instructed on the collection procedures. Subjects were blind to the glucometer readings during the entire study. Data was stored and time stamped by each glucometer for later download and data management.

Work shift activity was quantified from CSA activity monitors using the method established by Heil (MME 33(5):s168, 2001).

Data were analyzed using a two way repeated measures Anova. Apriori planned comparisons were used to evaluate differences between the trials at the various time points. Statistical significance was evaluated at $p<0.05$.

Results/Conclusions

Figure 1 shows that when 40 $g.hr^{-1}$ of a liquid carbohydrate solution is consumed there is maintenance of blood glucose when compared to a placebo during 12 hours of arduous wildfire suppression compared to placebo.

The most dramatic difference in blood glucose occurs at six hours post breakfast but is even greater late in the afternoon (at four and six hours post lunch) during increased fire activity when fire line operations are most hazardous.

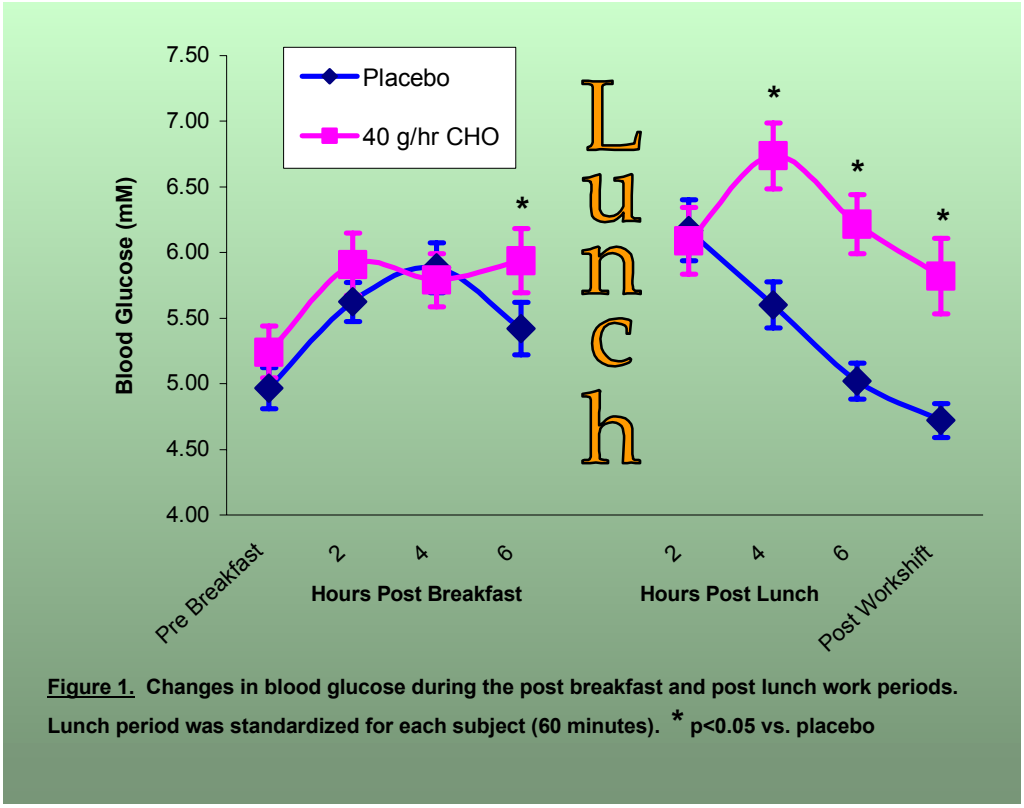

Figure 1. Changes in blood glucose during the post breakfast and post lunch work periods. Lunch period was standardized for each subject (60 minutes). * $p<0.05$ vs. placebo

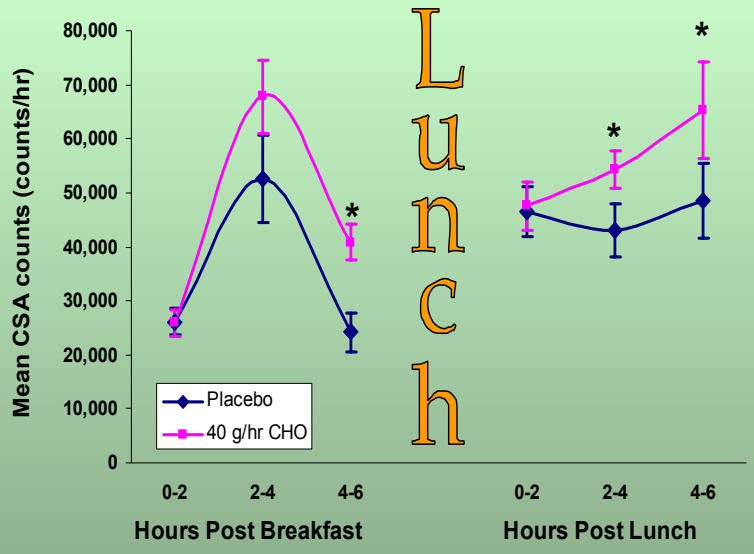

Figure 2. **Mean CSA counts (counts/hour) during the post breakfast and post lunch periods of the 12 hour workshifts. *p<0.05 vs. Placebo.**

Figure 2 shows the mean activity monitor counts for each two hour period during the day. The work rate recorded by the activity monitors show a significant reduction in the work done by the placebo group compared to the CHO group for the final two hours of the morning shift and the final four hours of the afternoon shift. The reductions in work output parallel the drop in blood glucose. These data show that ingesting a carbohydrate solution increases late morning and afternoon work.

Figure 3 shows the total activity monitor counts for the entire day with and without CHO supplementation. These data show that total daily work is increased. The increased work is the equivalent of 1.75 hours extra hours of work each day above the work output when not receiving regular carbohydrate supplementation.

These data indicate the importance of supplemental CHO on work performance during extended arduous operations. Further research should determine the role of supplemental CHO on cognitive processing and decision-making during extended wildfire combat.

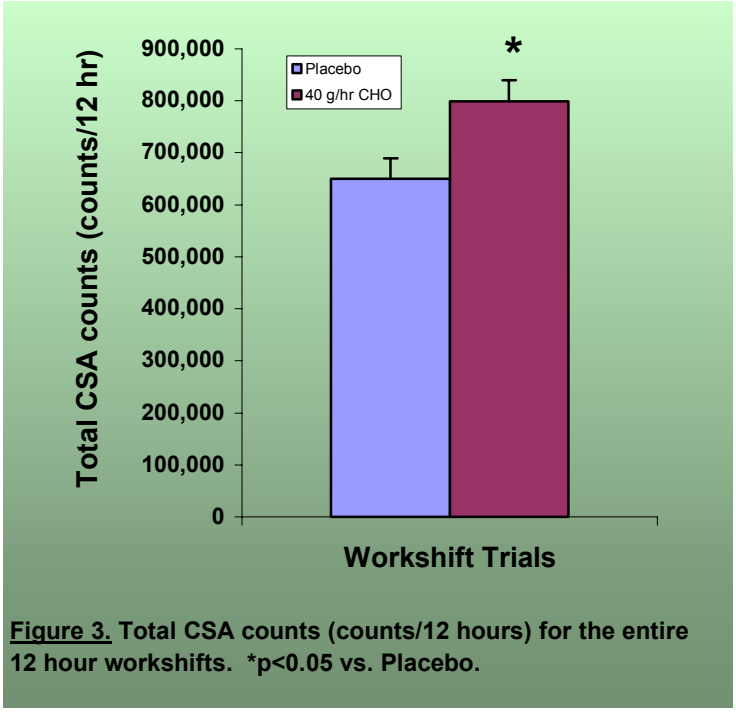

Figure 3. **Total CSA counts (counts/12 hours) for the entire 12 hour workshifts. *p<0.05 vs. Placebo.**

Acknowledgements

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