Case Study of Training, Fitness, and Nourishment of a Dog Driver During the Iditarod 1049-Mile Dogsled Race

Carla Cox, Steven Gaskill, Brent Ruby, and Sharon Uhlig

The purpose of the present case study was threefold: (a) to estimate intake and expenditure of a dog driver (musher) while participating in the Iditarod, (b) to determine the hydration status of the musher at the completion of the event, and (c) to evaluate training related changes in aerobic capacity and body composition of a long-distance dog sled driver in preparation for and following completion of a 1049-mile (1692-km) sled dog race. Actual energy intake during the Iditarod Sled Dog Race was estimated at 8,921 kilojoules (kJ) per day. Nutrient intake expressed as percentage kJ of total energy (14%, 44% and 42% for protein, carbohydrates, and fat, respectively). Weight loss of .72 kg of body weight indicated an energy deficit of 1819 kJ per day during the race. Total energy needs per day were calculated to be 10,740 kJ/day. An increase in hematocrit and hemoglobin during the race may indicate dehydration during the event. There was an improvement in aerobic fitness during on-snow training as determined by ventilatory threshold and VO$_{2peak}$ data. Fat-free mass was maintained during training (46.4 kg), with a concomitant decrease in fat (2.4 kg). Fat-free mass was also maintained during the 12-day race.

Key Words: musher, dog sled driver, energy intake, energy balance, VO$_{2peak}$

Introduction

In preparation for the 1049-mile (1692 km) Iditarod sled dog race, dog sled drivers (mushers) often train their dogs for over 2419 km from September through March. Before snowfall, the dogs are trained by pulling a four-wheeled all terrain vehicle (ATV). The work of the musher at this point includes carrying the dogs from their circle (where they are tied) to the main line, harnessing the dogs, and hooking them into the main line. In addition to harnessing and hooking up the dog team, the musher often helps the team by pumping (pushing with one leg, while maintaining balance on the sled) and running. Besides the physical work of training the dogsled team, buckets of food and water are carried to the dogs throughout the year, a significant task because there are often more than 70 dogs per kennel.
As elite sled dogs reach their maximum potential through specialized breeding programs, excellent feeding regimens and scientifically designed canine physical training programs, the importance of the fitness and nutrition of the driver may emerge as the critical component to winning dog sled races. Well-trained drivers who are able to maintain their fat-free mass, weight, and hydration during the event could maximize their ability to assist the dog team and improve team performance.

Each year, the Iditarod sled dog race begins in Anchorage the first weekend of March, runs through mountainous sections of remote Alaska, and finishes on a coastal section of the Bering Sea. The race is continuous, except for two mandatory 8-hour rests and one 24-hour rest. Mushers generally complete the race in 9 to 14 days. Food for the dogs and drivers is shipped ahead to checkpoints along the trail. The mushers do not receive any outside assistance and must care for their dogs’ needs as well as their own. During the race, the musher helps the team negotiate rough trails, which includes many hills, hummocks, and potholes. Often the trail is heavily rutted as well. Jumping off the sled to miss a tree, running up the hills to decrease the load the dogs must pull, pushing and hanging onto the sled—all require aerobic fitness and strength. Mushers have been known to break trail with snowshoes and to require crampons to negotiate icy areas. In addition, there are the daily tasks of watering, feeding, and generally caring for the dogs, which increase the day-to-day energy expenditure of the competitor. Physical work for 18 hours per day is not unusual. In addition, heavy clothing is required to combat the environmental extremes of Interior Alaska (temperatures often reach –45°C), which contributes to the total energy expenditure of the musher. The drivers usually maintain a rigorous schedule, with little time for rest. Often mushers will run through the night and rest during the day if the weather is too warm for the dogs.

Although there are multiple articles written on the energy expenditure of the sled dog (7, 8, 12, 17), there is an absence of information on the fitness level and energy expenditure of the dog sled driver during training and participation in a long-distance event. Previous estimates of energy expenditure during mushing have been derived from retrospective food journals of arctic explorers who used sled dogs, often with heavy loads, negotiating difficult, ungroomed terrain. (4, 5, 10, 20). This information is of interest but has minimal application to the energy needs of the musher using state of the art sleds and lighter loads while often covering a distance of more than 161 km per day. To our knowledge, no one has attempted to gather energy intake data on mushers in an endurance event and to establish the level of hydration of the musher at the completion of the event. In addition, the fitness level of the driver has not been researched.

In 1993, Case (1) demonstrated a decrease in body weight and fat during the Iditarod Sled Dog Race among 10 participants. Using bioelectrical impedance, Chapman (2) demonstrated a decrease in total body fat during the Iditarod Sled Dog Race in 4 female and 13 male mushers of middle age. Additional research has evaluated the psychological stress encountered by the endurance musher (19). Racers displayed slowing of psychomotor activity, impairment of recent memory and temporal disorientation. A reduction in total blood cholesterol and serum protein values and an increase in muscle enzymes (creatine phosphokinase, serum glutamic-oxalacetic transaminase, and lactic dehydrogenase) have also been described during extended sled dog racing (15).

The purpose of the present case study was threefold: (a) to estimate energy intake and expenditure of a musher while participating in the Iditarod, (b) to determine
the hydration status of the musher at the completion of the event, and (c) to evaluate training related changes in aerobic capacity and body composition of a long-distance musher in preparation for and following completion of a 1049-mile (1692-km) sled dog race.

**Methodology**

This study was approved by the Institutional Review Board (IRB) of the University of Montana. One 49-year-old female musher was recruited for the case study. The subject had completed a wide variety of distance sled dog races, including participation in the Iditarod. Prior to fall training, she had been involved in a weight-training program. She was an active individual but did not participate in a planned aerobic exercise program prior to or during sled dog training. An approved consent form was completed and signed by the participant prior to beginning testing. The subject began on-snow sled training with dogs at the beginning of December 2000.

Food intake data were recorded using a simplified food journal. Due to the exhaustive nature of the race, ease of recording food intake was essential. Most of the food was prepackaged and shipped to the race checkpoints more than a month ahead of time. This prepackaging of the food provided the opportunity to record food intake by means of a check-off list, which would allow the subject to determine if one quarter, one half, three quarters, or all of the packaged food items had been consumed (Figure 1). Some check points provided an option of home-cooked meals for the mushers. Items that were eaten in addition to the packaged items were recorded in the back of the log book. The dietary record was analyzed using the *Food Processor*® Version 7.3 program (ESHA Research, Salem, Oregon, USA).

Calculation of total body expenditure was accomplished using the total energy intake data (above), averaged over the 12 days of the race. This information was combined with the weight-loss data (weight loss sustained after 48 hours, allowing for rehydration) to determine total energy needs per day.

A blood sample was analyzed for hematocrit and hemoglobin at a state certified laboratory prior to on-snow training to aid in the determination of hydration status. The same data were collected at the end of the training period, prior to leaving for the Iditarod Sled Dog Race. Within 1 hour of completing the Iditarod, an additional sample was obtained (Figure 2). The hematocrit and hemoglobin were determined using a Coulter Max M. The hemoglobin was determined photometrically.

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<th>Skwentna</th>
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<tr>
<td>Spaghetti</td>
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<td>Pizza</td>
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<td>Creamed carrots</td>
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<td>Meatloaf</td>
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<td>Horrible bar</td>
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<tr>
<td>Cupcake</td>
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</table>

Figure 1 — Food record provided to subject to coincide with the food drop at the checkpoint. Simplicity was the focus. The food was prepackaged by the subject and mailed to the checkpoint ahead of time by the Iditarod race committee.
The hematocrit was calculated (measured red blood cell count × mean corpuscular volume/10).

Anthropometric measures and measures of aerobic capacity were completed at the Human Performance Laboratory at the University of Montana in mid December, mid February, and at the end of March. Additional weights and anthropometric measurements were determined at the completion of the race in Nome, with the subject’s weight measured at the Norton Sound Hospital. Height and weight were measured with the subject dressed in Capilene® long underwear. All weight determinations were made on calibrated balance beam scales. Measurements were made prior to training, at the end of training, immediately after the event, and 24 and 48 hours after the event. Body fat was estimated using skinfold calipers (Lange) and hydrostatic weighing. Skinfold measurements were taken on the right side of the body and done by the same researcher at every visit. Measurements were taken on three sites: thigh, suprailium, and triceps. The Jackson and Pollack formula was used to determine body density (9). Percent body fat was calculated using the age-gender specific formulas suggested by Heyward and Stolarczyk (6). Two hydrostatic measurements were taken prior to the actual test to familiarize the subject with the underwater technique. Three weights were averaged to determine body density using the Lohman formula (13). Residual volume was determined using the Goldman and Becklace formula (14). Caliper measurements were taken prior to on-snow training, prior to leaving for the Iditarod Sled Dog Race, immediately after the completion of the event, and upon return home 11 days after the event (Figure 2). Hydrostatic measurements were taken prior to on-snow training and 11 days after the completion of the race (Figure 2).

To determine oxygen consumption at peak effort ($\text{VO}_2^{\text{peak}}$) and ventilatory threshold ($\text{VO}_2^{\text{VT}}$), the subject was exercised on the treadmill using the Balke protocol. Oxygen consumption was measured continuously during treadmill walking using a Parvo Medics metabolic cart (Salt Lake City, UT, USA). The metabolic cart was calibrated before each test with known concentrations of $\text{O}_2$ (15.2%) and $\text{CO}_2$ (5.17%). Expired gases were averaged and recorded every 15 s. $\text{VO}_2^{\text{peak}}$ was determined by noting the maximum $\text{O}_2$ uptake at the point at which the subject felt as though the maximum workload had been reached. The ventilatory threshold (VT) was determined by the first break, where a transition in the relationship between $\text{VCO}_2$ and $\text{VO}_2$ occurred. VT was selected independently by two separate investigators. Ratings of perceived exertion (RPE) were determined by asking the subject her perceived level of effort on a 20-point scale at each incremental raise of the treadmill. The subject was measured at her three visits to the laboratory: prior to on-snow training, prior to leaving for the event, and after returning home (11 days after the race; Figure 2).
Results

Energy intake was calculated at 8,921 kilojoules (kJ) per day. Nutrient intake expressed as percentage kJ of total energy was estimated at 14%, 44%, and 42% for protein, carbohydrates, and fat, respectively. Energy deficit based on a sustained weight loss of .72 kg for 48 hours after the event was estimated at 23,285 kJ during the 12.8-day race, for an average deficit of 1819 kJ/day.

Table 1 shows energy intake and macronutrient consumption data. Weight loss during the Iditarod sled dog race, from the start of the race to immediately after completing the event, was 3 kg (Table 2). Two days were allowed for rehydration. Weight immediately after the race was 54.0 kg. A total of 2.3 kg was regained within 24 hours, and weight was stable for 48 hours. Although direct measurement of hydration was not tested, the subject gained 4% of her body weight within 24 hours after the end of the race. Blood chemistry data are shown in Table 3. Hematocrit rose from 37.5% to 38.5%.

Fitness data are shown in Table 4. $\text{VO}_2\text{peak}$ increased during the on-snow training by 20.6% (40.7 ml/kg/min to 49.1 ml/kg/min). $\text{VO}_2\text{VT}$ improved 15% with a concurrent increase in grade of 1% during on-snow training. On return from the race, $\text{VO}_2\text{peak}$ had almost returned to pre-training levels but was still elevated over baseline (42.37 ml/kg/min). $\text{VO}_2\text{VT}$ returned to pre-training levels within 11 days of

Table 1 Average Energy and Nutrient Intake During the 12.8-Day Iditarod Dog Sled Race

<table>
<thead>
<tr>
<th>Macronutrient intake</th>
<th>Protein</th>
<th>Carbohydrate</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>g · d$^{-1}$</td>
<td>74.5</td>
<td>235.6</td>
<td>98.2</td>
</tr>
<tr>
<td>g · kg$^{-1}$bw · d$^{-1}$</td>
<td>1.3</td>
<td>4.1</td>
<td>1.7</td>
</tr>
<tr>
<td>% total</td>
<td>14</td>
<td>44</td>
<td>42</td>
</tr>
</tbody>
</table>

Note. Total intake = 8,921 kJ · d$^{-1}$.

Table 2 Weight Changes During Training and Racing

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre on-snow training (mid Dec.)</th>
<th>Prior to leaving for the race (mid Feb.)</th>
<th>Immediately after the race (mid March)</th>
<th>24 hours after the race (mid March)</th>
<th>10 days after the race (end of March)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)</td>
<td>59.5</td>
<td>57.0</td>
<td>54.0</td>
<td>56.3</td>
<td>57.6</td>
</tr>
</tbody>
</table>
Table 3  Hemoglobin and Hematocrit Values

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre on-snow training (mid Dec.)</th>
<th>Prior to leaving for the race (mid Feb.)</th>
<th>10 days after the race (end of March)</th>
<th>Normal laboratory values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (g/dl)</td>
<td>12.8</td>
<td>13.1</td>
<td>13.2</td>
<td>12 to 16</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>37.5</td>
<td>37.5</td>
<td>38.5</td>
<td>36 to 48</td>
</tr>
</tbody>
</table>

Table 4  Changes in Maximal and Submaximal Aerobic Fitness in Terms of VO$_{2\text{peak}}$ and Ventilatory Threshold

<table>
<thead>
<tr>
<th>Variable</th>
<th>Prior to training on snow</th>
<th>Prior leaving for the Iditarod</th>
<th>10 days after returning</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO$_{2\text{peak}}$ (ml/kg/min)</td>
<td>40.7</td>
<td>49.1</td>
<td>42.4</td>
</tr>
<tr>
<td>VO$_{2\text{VT}}$ (ml/kg/min)</td>
<td>34.5</td>
<td>40.5</td>
<td>35.1</td>
</tr>
</tbody>
</table>

Of note, the subject started on-snow training in good condition (40.7 ml/kg/min).

Skinfold measurement results indicated fat-free mass was maintained during training (46.4 kg), with a concomitant decrease in fat (2.4 kg). During the race, fat-free mass was maintained based on skinfold measures collected immediately post race.

Discussion

Energy intake was determined using a check-off system. This system could be used in other events in which prepackaged foods are used—for example, mountain climbing expeditions. The total kJ needs were calculated to be 10,740 kJ per day, based on total intake and accounting for weight loss sustained 48 hours after the event. Resting metabolic rate for the subject’s height, weight, and age using the Harris Benedict Equation was estimated, with an additional 10% for thermic effect of food and 70% for extreme activity, resulting in an estimated total energy need of 9962 kJ per day. However, our determinations estimated by energy balance data on the subject revealed an even higher energy requirement of 10,740 kJ/day for the subject. This illustrates the high energy demands of this sport. The subject’s carbohydrate intake was low (4.1 g/kg/day). Considering the extended physical activity required of the musher, a higher carbohydrate intake is suggested to maintain muscle and liver glycogen and overall performance, similar to athletes in other sports requiring physical endurance (16).
Based on pre-race and post-race hematocrit and hemoglobin, plasma volume decreased by 2.3% (Table 3). This would support the weight-gain concept of dehydration noted at the completion of the event when the subject gained 2.3 kg within 24 hours.

During training, the subject performed all the tasks of caring for her dog team, including training, feeding, watering, and hooking up the team and putting them back in the dog yard when the training session was completed. All of these physical activities probably contributed to the level of fitness prior to on-snow training. The increase in fitness resulting from on-snow training may be related to pumping and running with the sled, which occurred during on-snow training versus training with a four-wheeled ATV in the fall. As the on-snow training season progressed, training increased in both intensity and duration. The results of this study indicated an increase in VO_{2peak} and VO_{2VT} (Table 4). The large increase is difficult to explain. The subject does have asthma and, although her use of medicine was consistent throughout, it is possible that the environmental condition and the use of the inhaler may have influenced the results.

These data agree with the work of Chapman (2), who illustrated, through bioelectrical impedance (BIA), maintenance of lean body mass and loss of fat during the same race in 1990. Lean body mass was maintained during the duration of the training and event, with a decrease in total body weight. However, the accuracy of BIA is compromised if the hydration status of the subject changes (11).

Hydration is difficult to maintain with exercise in the cold environment. Fluid must be kept in insulated containers such as a thermos or insulated cover. This makes access to fluid more difficult. While running the team, both hands are never free to unscrew lids and unzip insulated covers because one hand must always be on the sled. In addition, it is very challenging to urinate in the cold environment and while running the sled, so the incentive is to minimize this somewhat complicated task. Levels of hydration were not checked throughout the race, but significant weight gain (4%) was noted within 24 hours of the end of the race and remained stable, indicating adequate rehydration. Water loss of as little as 2% of body weight is known to affect performance (18), so maintenance of body fluids should be a high priority and could have possibly improved our subject’s performance.

It is apparent that physical training, adequate dietary intake, and fluid balance contribute to the optimal performance of the musher. If the dog sled driver is using a handler to accomplish much of the training, an individualized exercise training schedule should be considered for the musher. In addition, adequate intake of kilojoules, with special emphasis on carbohydrates and hydration during an endurance race, may enhance the overall performance of the whole team. Further studies using doubly labeled water to accurately quantify total energy expenditure are required to determine the unique dietary needs of this group of athletes.

References


**Acknowledgments**

A huge thank you to the subject for her willingness to be prodded, poked, and run on the treadmill to exhaustion. Thank you to the Western Montana Clinic, Missoula, Montana, and the Norton Sound Hospital Laboratory, Nome, Alaska, for their donation and help in analyzing the blood data. Thank you to Dustin Slivka, graduate student in Health and Human Performance at the University of Montana, for his help with the metabolic cart.