Hyponatremia in a Cold Weather Ultraendurance Race

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Abstract
We assessed the incidence and etiology of hyponatremia in the 100-mile (161 km) Iditasport ultramarathon. Subjects (8 cyclists, 8 runners) were weighed and serum sodium was measured pre- and post-race. Race diets were analyzed to determine fluid and sodium consumption. Subjects were split by post-race serum sodium concentration into hyponatremic and normonatremic groups for statistical analyses. Seven of 16 subjects (44%) were hyponatremic. The hyponatremic group exhibited a significant decrease in serum sodium concentration (137.0 to 132.9 mmol/L, and the normonatremic group experienced a significant decrease in weight (82.1 to 80.2 kg) pre- to post-race. The hyponatremic group drank more fluid per hour (0.5 versus 0.4 L/h) and consumed less sodium per hour (235 versus 298 mg/h) compared to the normonatremic group. In conclusion, hyponatremia is common in an ultraendurance race held in the extreme cold, and may be caused by excessive fluid consumption and/or inadequate sodium intake.

Keywords
hyponatremia, ultraendurance, race diet, sodium consumption, ultramarathon

Disciplines
Other Medicine and Health Sciences | Sports Sciences

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Hyponatremia in a Cold Weather Ultraendurance Race

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ABSTRACT

We assessed the incidence and etiology of hyponatremia in the 100-mile (161 km) Iditarod ultramarathon. Subjects (8 cyclists, 8 runners) were weighed and serum sodium was measured pre- and post-race. Race diets were analyzed to determine fluid and sodium consumption. Subjects were split by post-race serum sodium concentration into hyponatraemic and normonatraemic groups for statistical analyses. Seven of 16 subjects (44%) were hyponatraemic. The hyponatraemic group exhibited a significant decrease in serum sodium concentration (137.0 to 132.9 mmol/L), and the normonatraemic group experienced a significant decrease in weight (82.1 to 80.2 kg) pre- to post-race. The hyponatraemic group drank more fluid per hour (8.5 versus 6.4 L/h) and consumed less sodium per hour (235 versus 298 mg/h) compared to the normonatraemic group. In conclusion, hyponatremia is common in an ultraendurance race held in the extreme cold, and may be caused by excessive fluid consumption and/or inadequate sodium intake.

INTRODUCTION

Hyponatremia, defined as a serum sodium level below 135 mmol/L, is a serious consequence of endurance events lasting longer than six hours. Possible signs and symptoms include light-headedness, nausea, vomiting, malaise, exhaustion, altered mental status, headache, seizures, and in extreme cases, death. Figure 1 shows the two leading theories that attempt to explain the hypotremia associated with prolonged exercise (1.3.4). One theory suggests that hyponatremia is caused by an increased in total body water, resulting from excessive fluid consumption or a failure to excrete excess volume. The second theory suggests that a decrease in sodium content resulting from excessive sodium loss in sweat or inadequate sodium intake causes hyponatremia. These two theories are not mutually exclusive. Any combination of the factors displayed in Figure 1 could lead to the development of hypotremia. Numerous papers have been published on the occurrence of hyponatremia in triathletes (2,5-12), ultramarathoners (13-17), marathoniens (18-20), Grand Canyon hikes (21,22), military recruits (23,24), and subjects in laboratory studies (25,26). All of these events took place in mild to hot environments, and the studies did not include an analysis of race diets to determine both fluid and sodium consumption.

In this study, we assessed the incidence of hyponatremia in the Iditarod, a 100-mile (161 km) ultramarathon race held in Alaska each February. Additionally, race diets were analyzed to determine racers' fluid and sodium consumption.

METHODS

The study was approved by the McDaniel College Institutional Review Board. All 122 entrants in the 2000 Iditarod Human Powered Ultra-Marathon...
th were invited to participate in the study at the a mandatory information meeting held two days prior to the race. Sixteen athletes (eight cyclists and eight runners) volunteered to be subjects and gave their written informed consent. All pre-race measurem ent were made at the information meeting. Measurements during the race ranged from -8°C to 4°C. The cyclists and runners competed on the same 100-mile (161 km) snowpacked course that winds through the Alaska Range. Race checkpoints were located approximately every 15-20 miles (24-32 km), where food and fluid were available. In addition, athletes were required to carry 15 pounds (7 kg) equipment at all times, including two liters of fluid in an insulated container, and 3000 kcal of food. Post-race measurements were made within 15 minutes of each athlete completing the race.

Pre- and post-race weight was measured using the Tanta Body Fat Monitor/Scale (TBF-622), accurate to 0.1 kg. Pre- and post-race blood samples were collected by routine venipuncture, with athlete s in a sitting position. Duplicate hematocrits were measured immediately on the samples using standard procedures. Assays for serum sodium concentra tion were carried out at the Carroll County General Hospital Medical Laboratory in Westminster, MD with a Spectra Ion Selective Electrode analyzer using standard methods and the manufacturer’s reagents on serum that was obtained by centrifugation, frozen immediately on dry ice, and stored at -20°C until thawed for analysis. Changes in plasma volume were calculated accord ing to the formula of van Beunom (27): % change plasma volume = [100(100 - hematocrit(m)) / hematocrit(n)] - [100(100 - hematocrit(n)) / hematocrit(m)], where hematocrit(m) and hematocrit(n) are pre-race and post-race hematocrit samples, respectively.

Subjects carried out a complete dietary recall of food and fluid consumption immediately following the race. Competitors were required to carry all their garbage to the finish line, so during the dietary recall, it was possible to count the number and type of food wrappers in each subject’s garbage bag. This process helped to ensure the accuracy of the dietary recall. The race diets were analyzed using the Nutritionist Five computer program (First Data Bank). Food items that were not listed in the Nutritionist Five program were added to the program using the nutrition facts from the food wrappers. Additionally, the recipes for specific foods that were available at checkpoints during the race were added to the program to assess the nutritional content.

Immediately following the race, subjects were interviewed to determine which, if any, hypotremia (light-headedness, nausea, vomiting, malaise, exhaustion, altered mental status, seizures, head- ache) (2) or gastrointestinal (nausea, vomiting, diarrhea, cramps) (28) symptoms they experienced during the race.

Subjects were split by post-race serum sodium concentration into hypotremic (serum sodium concentration < 135 mmol/L) and normotremic (serum sodium concentration ≥ 135 mmol/L) groups (1) for statistical analyses. Comparisons between the hypotremic and normotremic groups were made using unpaired t-tests, while comparisons within each group (pre- and post-race measure ments) were accomplished using paired t-tests. Statistical significance was set at p ≤ 0.05 for all analyses.

RESULTS

Table 1 shows descriptive characteristics of the hypotremic (serum sodium concentration < 135 mmol/L; n = 7) and normotremic (serum sodium concentration ≥ 135 mmol/L; n = 9) groups. The hypotremic group included three male cyclists, two male runners, one female cyclist, and one female runner, with an average finish time of 25.7 hours. The normotremic group included four male cyclists and five male runners, with an average finish time of 29.2 hours. All subjects reported experiencing at least one symptom of hypotremia, whereas 43% of the hypotremic and 67% of the normotremic group complained of gastrointestinal distress during the race. As shown in Table 2, the hypotremic group was significantly lighter than the normotremic group both pre-race (71.0 kg versus 82.1 kg) and post race (70.2 kg versus 80.2 kg). The hypotremic group exhibited a significant decrease in weight pre to post-race (-1.9 kg). The hypotremic group did not experience a significant change in weight. The hypotremic group exhibited a significant decrease in serum sodium concentration pre to post-race (137.0 mmol/L to 132.9 mmol/L) (Table 2). Six of the seven subjects had mild hypotremia (post-race serum sodium concentration ranged from 132-134 mmol/L) (2), and one subject had severe hypotremia (post-race serum sodium concentration = 129 mmol/L) (2). None of the athletes required medical attention. Both the hypotremic and normotremic groups exhibited a statistically significant decrease in hematocrit pre- to post-race (hypotremic group: 42.4 to 39.8; normotremic group: 42.9 to 41.2). Plasma volume increased in both the hypotremic (+12.4 ± 19.3%) and normotremic (+9.0 ± 20.9%) groups post-race. A comparison of the race diets of the hypotremic and normotremic groups is shown in Table 3. No statistically significant differences were seen. However, the hypotremic group consumed fewer kcal (212 versus 252 kcal/kg), less sodium (235 versus 298 mg/kg), and drank more liters of fluid (0.5 versus 0.4 L/kg) compared to the normotremic group.

DISCUSSION

This study represents the first report of the incidence of hypotremia in a cold weather ultramarathon event. Hypotremia occurred in 44% of the Iditarod athletes in this study, which is

### Table 1. Descriptive characteristics; values expressed as mean ± SD.

<table>
<thead>
<tr>
<th>Hypotremic</th>
<th>Normotremic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>(n = 7)</td>
</tr>
<tr>
<td>Male</td>
<td>5</td>
</tr>
<tr>
<td>Female</td>
<td>2</td>
</tr>
<tr>
<td>Age (y)</td>
<td>35.9 ± 9.7</td>
</tr>
<tr>
<td>Division</td>
<td>4 bike</td>
</tr>
<tr>
<td></td>
<td>3 foot</td>
</tr>
<tr>
<td>Finish time (h)</td>
<td>25.7 ± 8.3</td>
</tr>
<tr>
<td>Hypotremia symptoms</td>
<td>100%</td>
</tr>
<tr>
<td>Gastrointestinal symptoms</td>
<td>43%</td>
</tr>
</tbody>
</table>

### Table 2. Pre- and post-race weight and blood values; values expressed as mean ± SD.

<table>
<thead>
<tr>
<th>Hypotremic</th>
<th>Normotremic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-race weight (kg)</td>
<td>71.0 ± 7.3</td>
</tr>
<tr>
<td>Post-race weight (kg)</td>
<td>70.2 ± 7.3</td>
</tr>
<tr>
<td>Absolute weight change (kg)</td>
<td>-0.8 ± 1.0</td>
</tr>
<tr>
<td>Percent weight change (%)</td>
<td>-1.1 ± 1.5</td>
</tr>
<tr>
<td>Pre-race serum sodium (mmol/L)</td>
<td>137.0 ± 1.7</td>
</tr>
<tr>
<td>Post-race serum sodium (mmol/L)</td>
<td>132.9 ± 1.9</td>
</tr>
<tr>
<td>Pre-race hematocrit</td>
<td>42.4 ± 3.5</td>
</tr>
<tr>
<td>Post-race hematocrit</td>
<td>39.8 ± 2.3</td>
</tr>
</tbody>
</table>

*p ≤ 0.05 pre-race hypotremic and normotremic weight
*p ≤ 0.05 pre-race hypotremic and normotremic weight
*p ≤ 0.05 pre-race normotremic and post-race normotremic weight
*p ≤ 0.05 pre-race hypotremic and post-race hypotremic serum sodium
*p ≤ 0.05 post-race hypotremic and post-race normotremic serum sodium

Figure 1. Possible causes of hypotremia. Figure modified from Montain (1).
Table 3. Race diet; values expressed as mean ± SD.

<table>
<thead>
<tr>
<th></th>
<th>Hypornatremic (n = 7)</th>
<th>Normonatremic (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total kcal</td>
<td>5,481 ± 2,499</td>
<td>7,334 ± 5,322</td>
</tr>
<tr>
<td>Kcal/h</td>
<td>212 ± 64</td>
<td>252 ± 166</td>
</tr>
<tr>
<td>Percent carbohydrate (%)</td>
<td>69.0 ± 16.1</td>
<td>68.0 ± 14.4</td>
</tr>
<tr>
<td>Percent fat (%)</td>
<td>21.7 ± 16.4</td>
<td>22.4 ± 11.6</td>
</tr>
<tr>
<td>Percent protein (%)</td>
<td>9.1 ± 2.5</td>
<td>9.6 ± 4.1</td>
</tr>
<tr>
<td>Total Na+ (mg)</td>
<td>6,216 ± 3,299</td>
<td>8,558 ± 4,730</td>
</tr>
<tr>
<td>Na+ (mg/h)</td>
<td>235 ± 92</td>
<td>298 ± 144</td>
</tr>
<tr>
<td>Total fluid (L)</td>
<td>11.9 ± 5.7</td>
<td>12.2 ± 4.0</td>
</tr>
<tr>
<td>Fluid/h (L)</td>
<td>0.5 ± 0.2</td>
<td>0.4 ± 0.2</td>
</tr>
</tbody>
</table>

a higher percentage than has been reported for athletes participating in triathlons or ultramarathons held in mild to hot environments. Speedy (2) and Miller (6) reported that hyponatremia occurs in 18- 27% of race participants, and others (7,8,16) have found that 9-36% of athletes who seek medical care are hyponatremic. It is interesting to note that the hyponatremic athletes were significantly lighter than the normonatremic athletes, and that the two female subjects in the normonatremic group did not develop hyponatremia. These results confirm the findings of others (1,2,9) that women and smaller individuals are more at risk for developing hyponatremia because they need to consume less fluid than larger individuals to dilute serum sodium to hyponatremic levels. All of the hyponatremic and normonatremic athletes in the present study were instructed at least once of the signs and symptoms of hyponatremia. This is not surprising since the signs and symptoms of the condition (light-headedness, nausea, vomiting, malaise, ex- haustion, alteration of mental status, headache, and sei- zures) (2) are very nonspecific.

Figure 1 shows the possible causes of hyponatremia, including an increase in total body water, resulting from excessive fluid consumption or a failure to excrete excess volume, and a decrease in sodium content, resulting from excessive sodium loss in sweat or inadequate sodium intake. The majority of reports (2,5,8-10,12,15,18,22-24) indicate that excessive fluid consumption is the most likely cause of hyponatremia, although others have suggested that a failure to excrete excess volume (7, 17,30) or excessive sodium loss in sweat (6,19,21) may be contributing factors.

We speculate that the hyponatremia seen in Idiast sport athletes is caused by fluid overload and/or inadequate sodium intake. The normono- natremic group experienced a statistically significant weight loss (-1.9 kg) during the race, com- pared to the hypono- natremic group that experienced a statistically insignificant weight loss (+0.8 kg). Others (9,11, 31) have reported that fluid weight loss during a long distance exercise may account for as much as 2 kg of weight lost during the event. Sources of nonfluid weight loss include loss of fat, glycogen, and water stored with glycogen. The corollary of this observation is that athletes who drink sufficiently to maintain their weight during an ultradistance event may in reality be overhydrated by 2 liters. This suggests that the hyponatremic Idiast sport athletes may have had a fluid excess of 1.2 L, and that the normonatremic athletes were essentially euhydrated.

Both the hyponatremic and normonatremic groups exhibited a decrease in hematocrit and an increase in plasma volume following the race, although these changes were more pronounced in the hypono- natremic group. These findings agree with the reports of others (5,9,10,23,25), and may be indicative of hypervolemia (9,10).

Race dietary analysis revealed that the hypono- natremic group drank more liters of fluid per hour (0.5 L/h versus 0.4 L/h) and consumed less sodium per hour (235 mg/h versus 298 mg/h) than the normonatremic group, although the differences were not statistically significant. The ACSM recommends that athletes drink 0.6-1.2 liters of fluid per hour during exercise, with the addition of 0.5-0.7 g of sodium per liter for exercise lasting more than one hour (32). Using these guidelines and an average finish time of 27:6h, the athletes in this study should have consumed 16.6-33.1 L of fluid and 6.3-23.2 g of sodium. Both the hyponatremic and the normonatremic groups consumed less fluid than the ACSM recommendations. However, the ACSM guidelines were established based on research from much shorter events than ultradistance competi- tions, and they are aimed at preventing heat injuries during events held in a hot environment. The guide- lines may be inappropriately high for any ultraendurance competition (33,34), and most cer- tainly are too high for an ultradistance endurance event held in Alaska in February. The hyponatremic athletes (6.2 g sodium) consumed less than the recommended amount of sodium, but the normonatremic athletes (8.6 g sodium) were within the ACSM guidelines, suggesting that inadequate sodium intake may have been a contributing factor in the development of hyponatremia.

It seems unlikely that the other possible causes of hyponatremia shown in Figure 1 could account for the hyponatremia seen in Idiast sport athletes. A failure to excrete excess fluid could be caused by excessive ADH, but it is known that ADH secretion is decreased in the cold (33). Hypothetically, hy- ponatremia can be caused by an excessive loss of sodium in sweat. There is little support for this theory in the literature for events occurring in hot environments (1), so it seems unreasonable to sug- gest that this is the cause of hyponatremia in an event held in the extreme cold, where athletes are in- structed at a mandatory pre-race meeting to avoid sweating in an attempt to prevent hypothermia and frostbite.

In conclusion, hyponatremia occurred in 44% of the athletes competing in an ultradistance event in the extreme cold. We speculate that the hypona- tremia was caused by excessive fluid consumption and/or inadequate sodium intake.

ACKNOWLEDGEMENT

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Author’s Note: These data were collected at the 2000 Idiast sport Human Powered Ultra-Marathon. In 2001, the name of the race was changed to the Susitna100.

REFERENCES


(continued on pg 62)
NEURILEMMOMA: AN UNUSUAL BENIGN TUMOR OF THE CERVIX

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Connie Kreiss, MD* Ann Commodore, RN⁴
Edward A. Barker, MD⁴

CASE PRESENTATION
A 47-year-old para 2 woman came for a routine examination and Pap smear in November of 2000. She was still having regular but somewhat heavier menstrual cycles, and had recently begun to experience some peri-menopausal symptoms. She had no intermenstrual bleeding, no postcoital bleeding and neither dysmenorrhea nor dyspareunia. She had no vaginal discharge and no gastro-intestinal complaints. Her only other gynecological complaint was an occasional feeling of heaviness in the pelvis with some urinary frequency and mild urgency. Her past history and family history was unremarkable.

She had never had an abnormal Pap smear and the previous normal smear was 3 years ago. She had a normal mammogram 3 years earlier. She was taking a low dose oral contraceptive pill. The general physical examination was entirely negative. There were no skin lesions, no lymph nodes and no evidence of Von Recklinghouse's disease.

On gynecologic exam the external genitalia were normal and so was the vagina. The cervix had a most unusual appearance, with a 2-cm diameter round, sessile tumor on the posterior lip. This tumor was soft, with a patchy yellow red appearance and seemingly vascular. It did not involve the endocervical canal.

At colposcopy, the entire squamo-columnar junction could be seen. The anterior lip of the cervix had an excretion but was otherwise normal. The tumor itself was uneroded and did not bleed on contact. It did not have any acetoc-white areas and other than being vascular did not show any abnormal vessels (figure 1-a and 1-b).

On bimanual examination the cervix was not tender. The tumor was soft without any induration of the surrounding areas. The tumor itself was normal in size, location and consistency. The adenexae felt normal and there was neither induration in the parametria, nor nodularity in the posterior fornix. A pap smear was taken and reported as normal.

ABSTRACT
Background: A Neurilemmoma (also called Schwannoma) is a benign, slowly growing neoplasm of the Schwann cells which may occur in association with any nerve. Its finding in the cervix of the uterus is extremely rare.

Case: At a routine annual exam, a 47-year-old woman was found to have a tumor on the posterior lip of the cervix. The patient was completely asymptomatic. The tumor was excised using a large electrical loop (LEEP) and found to be a benign Neurilemmoma. Subsequently a CT scan of the pelvis did not reveal any other abnormalities and no further treatment was contemplated.

Conclusion: A benign neurilemmoma can present on the cervix as a vascular appearing tumor. This is a most unusual location for this tumor which arises from the Schwann cell of a nerve sheet.

INTRODUCTION
Benign Neurilemmomas (also called Schwannomas) are benign and slowly growing neoplasms of the Schwann cells surrounding nerves. They may arise from nerve sheaths in any part of the body, but their occurrence in female reproductive tissues is very rare. We report a case of a benign neurilemmoma of the uterine cervix.

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