Body Mass and Composition Changes in Mountaineers After a Commercial Expedition on Denali (6194 m)

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ABSTRACT

Wagner DR. Body Mass and Composition Changes in Mountaineers After a Commercial Expedition on Denali (6194 m). JEPonline 2012;15(3):39-44. Sojourns to high altitude have resulted in weight loss, but there is a lack of data from guided commercial expeditions. The purpose of this study was to determine the body mass and composition changes in mountaineers after a commercial climbing expedition on Denali (6194 m). Eleven mountaineers began the expedition, and 8 (5 clients, 3 guides; 7 males, 1 female; age: 37.4 ± 10.1 yrs) completed the study; all 8 reached the summit. Pre- and post-data, spanning 21 days, were collected in Talkeetna, AK (105 m). Body mass and body fat percentage (%BF) were obtained with a full-body bioelectrical impedance scale. Every participant lost weight (-2.9 ± 1.4 kg, P = .001; -0.8 to -5.2 kg), and on average there was a significant drop in %BF (-3.0 ± 3.1% BF, P = .029). There was a tendency for the clients to lose more weight (-3.5 ± 1.1 kg vs. -2.0 ± 1.5 kg, P = .149) and %BF (-4.8 ± 1.4% BF vs. -0.1 ± 3.1% BF, P = .024) than the guides. Neither the pre-expedition mass nor %BF were significantly (P>0.05) correlated with the losses. Despite sleeping only 3 nights above 5000 m with no food restrictions, mountaineers lost a significant amount of mass and %BF during a 3-wk commercial expedition on Denali. Additional research is needed with a larger sample to make more definitive comparisons between groups of mountaineers (commercial vs. non-commercial expeditions, clients vs. guides, and males vs. females).

Key Words: Fat Mass, Fat-Free Mass, Climbing, Altitude
INTRODUCTION

A decrease in body mass is a well-known phenomenon of high-altitude mountaineering. Many theories and explanations have been put forth to explain this phenomenon, including inadequate energy intake due to lack of palatable food or the added burden of preparing food in a challenging environment, detraining from days spent in a tent, and the negative effect of hypoxia on protein metabolism (7). However, up to approximately 5000 m, a loss of body mass is thought to be avoidable by maintaining adequate calories (7).

Denali (6194 m), also known as Mt. McKinley, is the highest point in North America. It is a demanding mountaineering endeavor with an average trip length of 18.4 days in 2011 (4). Additionally, the extreme northern latitude of the peak (63°N) results in a lower barometric pressure and partial pressure of inspired oxygen than peaks of similar altitude in the Himalaya or Alps, which further adds to the difficulty for climbers (10). Weight loss at altitude is dependent on the altitude reached and the amount of time spent there (7), and Denali provides a sufficient stimulus to expect substantial weight loss. Indeed, previous investigators have reported significant losses of mass for mountaineers on this mountain (1,9). However, no data exist on guided climbers from commercial expeditions.

According to the National Park Service that oversees permits to climb Denali, guided climbing has become increasingly popular over the last decade and will likely continue to increase (4). Guided climbers have their food prepared by their guides, and it is available ad libitum. Therefore, it should be easier for these climbers to achieve adequate caloric intake. Also, despite rest days, climbers typically carry or haul large loads exceeding 45 kg on a regular basis. Thus, it is unlikely that detraining would lead to a loss of muscle mass on this mountain. The purpose of this study was to determine the body mass and composition changes in mountaineers resulting from a multi-week commercial climbing expedition on Denali. It was hypothesized that the climbers on this commercial expedition would lose less weight and retain more muscle mass than that reported by previous investigators of non-guided climbers (1,9).

METHODS

Subjects
The study sample consisted of a group of 11 mountaineers (8 clients, 3 guides) from one of the six commercial guiding services authorized to operate on Denali. All participants agreed to the study and signed an informed consent in Anchorage, AK. The study was approved by the Institutional Review Board of Utah State University.

Design and Procedures
Longitudinal data collection with pre- and post-measurements spanning 21 days was the research design. In the interim, the subjects took part in a mountaineering expedition on Denali. Food and beverages were available ad libitum. The guides prepared a cooked breakfast and dinner daily, and snacks (e.g., energy bars and cookies) were available throughout the day.

Data collection took place in Talkeetna, AK (105 m). Age and height were obtained by self-report. Body mass and body fat percentage (%BF) were measured with a full-body bioelectrical impedance (BIA) scale (HBF-500, Omron Healthcare, Bannockburn, IL) with participants barefoot and wearing a single base layer. Urine specific gravity (USG) was measured with a digital refractometer (PA202, Misco, Cleveland, OH) before the BIA assessment. A USG value of \( = 1.020 \) was considered euhydration (3), and was a requirement for the BIA assessment.
Statistical Analyses
The mean differences between pre- and post-measurements were evaluated using paired t-tests. Pearson’s product-moment correlation was used to evaluate the relationship between pre-measures and change scores. Statistical significance was accepted at the $P = 0.05$ level. All statistical analyses were run with SPSS (version 20, IBM, Armonk, NY). The sample size was limited by restrictions imposed by Denali National Park and Preserve. The size of climbing groups cannot exceed 12.

RESULTS
There were 21 days between baseline and post-expedition measurements. Due to planned rest days and bad weather, only 10 of the 21 days involved climbing or descending (Figure 1). Eight (5 clients, 3 guides) of the 11 climbers completed the expedition. Post-data are not available on the 3 that left the expedition early. All 8 climbers that remained reached the summit on the 17th day of the expedition. Data for these climbers are in Table 1.

Every subject lost mass (-0.8 to -5.2 kg, $-2.9 \pm 1.4$ kg, $P < 0.01$), and there was a significant drop in %BF (-3.0 ± 3.1% BF, $P = .03$). However, fat-free mass remained unchanged ($0.1 \pm 1.9$ kg, $P = .86$). There was a tendency for clients to lose more weight and %BF (-3.5 ± 1.1 kg, -4.8 ± 1.4% BF) than guides (-2.0 ± 1.5 kg, -0.1 ± 3.1% BF), but this pilot-study sample was not large enough to make a valid statistical comparison of these subgroups. Pre-expedition mass was not correlated with the

Figure 1. Altitude profile of expedition with highest altitude attained each day. × = Data collection, ? = rest or bad weather day with little physical activity, ? = climbing or descending day with heavy physical activity.
changes in mass \((r = -.68, P = .06)\) or \%BF \((r = -.37, P = .38)\). Similarly, pre-expedition \%BF was not correlated with weight change \((r = -.63, P = .09)\) or \%BF change \((r = -.09, P = .83)\).

### Table 1. Descriptive and change variables of sample \((N = 8)\)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sex</th>
<th>Status</th>
<th>Age (yr)</th>
<th>Pre-Mass (kg)</th>
<th>Post-Mass (kg)</th>
<th>Δ Mass</th>
<th>Pre-%BF</th>
<th>Post-%BF</th>
<th>Δ %BF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male</td>
<td>Client</td>
<td>45</td>
<td>63.2</td>
<td>60.8</td>
<td>-2.4</td>
<td>15.5</td>
<td>12.0</td>
<td>-3.5</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>Guide</td>
<td>25</td>
<td>73.0</td>
<td>72.2</td>
<td>-0.8</td>
<td>22.1</td>
<td>23.4</td>
<td>1.3</td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>Client</td>
<td>31</td>
<td>90.6</td>
<td>85.4</td>
<td>-5.2</td>
<td>27.2</td>
<td>24.0</td>
<td>-3.2</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>Client</td>
<td>44</td>
<td>88.3</td>
<td>84.7</td>
<td>-3.6</td>
<td>22.4</td>
<td>17.1</td>
<td>-5.3</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>Client</td>
<td>42</td>
<td>76.7</td>
<td>74.1</td>
<td>-2.6</td>
<td>17.8</td>
<td>12.1</td>
<td>-5.7</td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>Client</td>
<td>52</td>
<td>88.2</td>
<td>84.7</td>
<td>-3.5</td>
<td>22.0</td>
<td>15.7</td>
<td>-6.3</td>
</tr>
<tr>
<td>7</td>
<td>Male</td>
<td>Guide</td>
<td>36</td>
<td>76.8</td>
<td>73.2</td>
<td>-3.6</td>
<td>23.0</td>
<td>19.3</td>
<td>-3.7</td>
</tr>
<tr>
<td>8</td>
<td>Male</td>
<td>Guide</td>
<td>24</td>
<td>77.0</td>
<td>75.5</td>
<td>-1.5</td>
<td>18.2</td>
<td>20.3</td>
<td>2.1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>37.4 ± 10.1</td>
<td>79.2 ± 9.3</td>
<td>76.3 ± 8.4</td>
<td>2.9 ± 1.4</td>
<td>21.0 ± 3.7</td>
<td>18.0 ± 4.6</td>
</tr>
</tbody>
</table>

\(Δ = \text{change}; \%BF = \text{percent body fat}; \ast = P < 0.05\)

### DISCUSSION

Kayser (7) suggested that up to altitudes of ~5000 m weight loss could be avoided by maintaining an adequate diet, and malabsorption of nutrients is not a major consideration even at altitudes up to 6542 m (11). However, despite ad libitum access to calories and being above 5000 m for only 3 days, the climbers on this 3-wk Denali expedition lost an average of 3.6% of their mass. Other researchers that have measured weight changes following Denali expeditions have also reported losses. Bales et al. (1) reported a mean loss of 2.9 kg, the same amount as the present study. The climbers in Tanner and Stager’s study (9) lost an average of 4.2 kg (5.4% of mass) despite not being able to ascend above 4300 m during their 21-day expedition. The amount of weight lost in the present study of climbers on a commercial expedition appears to be similar to that of other Denali expeditions of similar duration.

There was a preferential loss of body fat. In fact, fat-free mass was spared completely. Other researchers have also found that the majority of mass lost during mountaineering expeditions is due to losses in fat with some loss in fat-free mass. Using skinfold and circumference measurements, Bales et al. (1) reported a \%BF loss similar to the present study and noted that there were losses in both fat mass and fat-free mass with the greater proportion of loss coming from fat. Likewise, Tanner and Stager (9), using hydrostatic weighing, reported that 77% of the body mass lost in their subjects was fat mass. However, this partitioning was almost completely reversed with the majority of loss attributed to decreases in fat-free mass when the assessment was made with skinfolds and magnetic resonance imaging. They concluded that the different body composition assessment methods produced inconsistent results and put more credence on the hydrodensitometry data. In their review of the literature they noted that, when studies are conducted in mountain laboratories or hypobaric chambers, the weight loss seems to be predominantly from fat-free mass. But, when the results are from climbing expeditions, then, the majority of loss is from fat mass.
The body composition methodology used in this study, foot-to-foot BIA, has questionable validity. Pribyl et al. (8) recently reported statistically significant inaccuracies in %BF estimations using the Omron HBF-500, the same model foot-to-foot BIA device used in the present study, compared to the Bod Pod in a sample of college students. Thus, there is some uncertainty about the precision of this method to detect small changes in fat and fat-free mass. For example, close inspection of the individual data (Table 1) reveal that subject 6 lost 6.1 kg of fat, but only 3.5 kg of mass. Thus, he would have had to gain 2.6 kg of fat-free mass in only 3 weeks. This is highly unlikely. Although the %BF data are questionable, mass was measured directly and thus, the mean weight change of -2.9 kg is presumed accurate.

Boyer and Blume (2) found that the amount of body mass and fat lost following many days at high altitude on a Mt. Everest expedition was correlated with initial body mass and fat, and Sherpas were not as susceptible to changes in mass and composition as Caucasian climbers. In contrast, the present study found that baseline weight and %BF were not significantly correlated with changes in either mass or %BF. Although there were no Sherpas in the present study, there was a tendency for the clients to lose more weight and body fat than the guides. Although this suggests that fitness or experience in the mountains may be a factor in retaining mass at altitude, the sample is too small to make a definitive statement.

**Strengths and Limitations**

The primary strength of this study is that it is the first known investigation of a commercial expedition. As a pilot study of a single expeditionary team, the generalizability of these results is limited. Nonetheless, the sample size of this pilot study was larger than the previously published study using data from a Denali expedition by Tanner and Stager (9). Another limitation was the body composition assessment method used. Pribyl et al. (8) questioned the accuracy of the Omron HBF-500 device, and the variability in hydration status is thought to be a source of error with the BIA method (6). Fulco et al. (5) reported an inconsistent result from BIA compared to hydrostatic weighing in a group of soldiers that had spent 16 days between 3700 and 4300 m. These researchers suggested that BIA should not be used to assess body composition at altitude due to a loss in total body water and fluid compartment shifts. To minimize this effect, subjects in the present study were tested the day after departing from the mountain rather than immediately after. Hence, the subjects had some time to rehydrate. Additionally, USG was assessed and had to be \( \geq 1.020 \), which is suggestive of euhydration (3) prior to the BIA procedure. Nonetheless, the BIA method could be a source of error.

**CONCLUSIONS**

Despite having guides prepare meals, guided climbers lost a significant amount of body mass with a preferential loss of body fat during a 3-wk expedition on Denali. The generalizability of these results is limited. More research is planned with a different assessment method to identify patterning of loss (upper body vs. lower body) and a larger sample to make more definitive comparisons between groups (guides vs. clients, commercial groups vs. non-commercial groups, and men vs. women).

**ACKNOWLEDGMENTS**

Thanks to the Human Movement Science Program of the Health, Physical Education, and Recreation Department at Utah State University for funding the publication fees associated with this work.
REFERENCES


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