

Original Paper

Effect of Environmental Change while Climbing Mt. Daisen on Forced Vital Capacity and Forced Expiratory Volume % in Young Women

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Abstract

The aim of the present study was to clarify the effects of environmental change while climbing Mt. Daisen on forced vital capacity and forced expiratory volume % in young women in summer. Seven healthy Japanese women (age: 22.6 ± 4.2 years) volunteered to climb Mt. Daisen (1,709 m), located in Tottori prefecture, in August. Participants' expiratory forced vital capacity (FVC), forced expiratory volume % (FEV_%) and arterial oxygen saturation (SpO₂) were measured at 4 points (Ground: 10 m, Rest point: 780 m, Summit: 1,709 m, Goal point: 780 m). The measurements were conducted soon after the subjects' arrival at each point. The degree of dyspnea sensation was measured at Ground, Rest point, Goal point and at each station. There were no significant changes in FVC. FEV_% at the summit was significantly lower than at the Ground and Rest point. No significant differences were found in SpO₂ at each measuring point. The degree of dyspnea sensation at each station soon after the subjects' arrival was significantly higher than those at the Rest point. The results of this study indicated mild airway contraction induced by stresses on the respiratory system from increasing exercise intensity during an ascent of Mt. Daisen.

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Introduction

Mt. Daisen (in Tottori Prefecture) is one of the top 100 Japanese Mountains (*Nihon Hyaku-meizan*), and the number of climbers is estimated at approximately 100 thousand per year [1]. Recently, incidents of accidents have seen a marked increase, such as respiratory disease initiation during the climbing of Mt. Daisen [1, 2]. Because of about a 1,000 meter difference of elevation between the starting point and the summit, climbers receive great physiological stresses during an ascent of Mt. Daisen. Therefore, increases in ventilation volume according to the exercise intensity leads to an increase in the stress of the respiratory system [3, 4]. The Japanese Society of Mountain Medicine had announced guidelines for prevention of respiratory disease initiation such as bronchial asthma, chest pain and spontaneous pneumothorax [4]. However, it has been suggested that airway obstruction was led by airway cooling induced by increases in ventilation air volume with increases of exercise intensity in normal individuals. Thus, normal individuals possibly have risks of causing difficulty in breathing, airway obstruction and hyperventilation syndrome while climbing mountains [4-7]. From aspects of preventive medicine, it is necessary to examine changes in respiratory functions during the climbing Mt. Daisen in summer because there is no previous research regarding respiratory changes in summer mountain climbing. Moreover, previous research targeted adult men, not women. Recently, increased numbers of young women have been interested in mountaineering. Thus, it is important to examine respiratory changes in young women. The aim of the present study was to clarify the effects of environmental change while climbing Mt. Daisen on forced vital capacity and forced expiratory volume % in young women.

Methods

Seven Japanese healthy young women (age: 22.6 ± 4.2 years, height: 158.3 ± 8.0 cm, weight: 53.1 ± 8.5 kg) volunteered to climb Mt. Daisen (1,709 m), located in Tottori prefecture, in August. Informed consent was obtained from all participants after explaining the study purpose and potential risks of the study protocol. Thus, each participant voluntarily joined this program.

Participants moved to the starting point of the mountain (Rest point, altitude: 780 m) from the University (Ground, altitude: 10 m) by car. They were ready for climbing at that point. Then, they started to ascend from the Rest point to the Summit (Summit: 1,709 m), from the 1st – 9th station (Table 1), and descended from the Summit to the Goal point (altitude: 780 m), from the 9th – 1st station, with a ten-minute rest at every station.

Participants' expiratory forced vital capacity (FVC), forced expiratory volume % (FEV_%) and arterial oxygen saturation (SpO₂) changes were measured at 4 points (Ground: 10 m, Rest point: 780 m, Summit: 1,709 m, Goal point: 780 m) using a spirometer (micro; VITAL) and pulse oximeter (SAT-2100; NIHON KODEN). Measurements were conducted soon after the subjects' arrival at each point. The degree of dyspnea sensation [9], pulse rate (by palpation) and rating of perceived exertion (RPE) [10] were measured at Ground, Rest point, Summit, Goal point and at each station. Atmospheric temperature and relative humidity were measured at the Rest point and at each station (Table 1). This investigation was accompanied by university teaching staff, paramedical personnel and health fitness instructors who have a lot of experience in climbing Mt. Daisen.

The data (FVC, FEV_%, SpO₂, pulse rate and RPE) were presented as mean \pm standard deviation and analyzed with one-way analysis of variance to examine differences between the means of the two groups. Results of the degree of dyspnea sensation were presented as the median. The Friedman test was performed to detect changes of the degree of dyspnea sensation within the group. Statistical significance was accepted at less than 0.05. The data were analyzed by SPSS ver. 12.0 for Windows.

Results

1. Altitude and meteorological conditions at each measuring point

Altitude and meteorological conditions were changed with respect to the mountain geographical environment (Table 1).

Table 1 Altitude and meteorological conditions while climbing Mt. Daisen

station	altitude (m)	temperature (°C)	relative humidity (%)	pressure (hPa)
Summit	1,709	20.7	87.6	834
station 9	1,620	23.9	65.0	839
station 8	1,580	24.8	63.1	845
station 7	1,420	25.7	71.2	859
station 6	1,350	25.9	73.1	867
station 5	1,245	24.2	74.5	879
station 4	1,170	24.9	84.4	889
station 3	1,070	24.0	79.8	897
station 2	970	24.5	70.4	906
station 1	865	26.6	68.3	918
Rest point	780	26.0	66.8	930

2. Changes of pulse rate and RPE

Figure 1 showed changes of pulse rate and RPE. Significant elevated pulse rate and RPE were observed at each station soon after the subjects' arrival as compared with those before departure ($p < 0.01$). Pulse rate and RPE at each station before the subjects' departure demonstrated higher readings than those at the Ground and Rest point ($p < 0.05$).

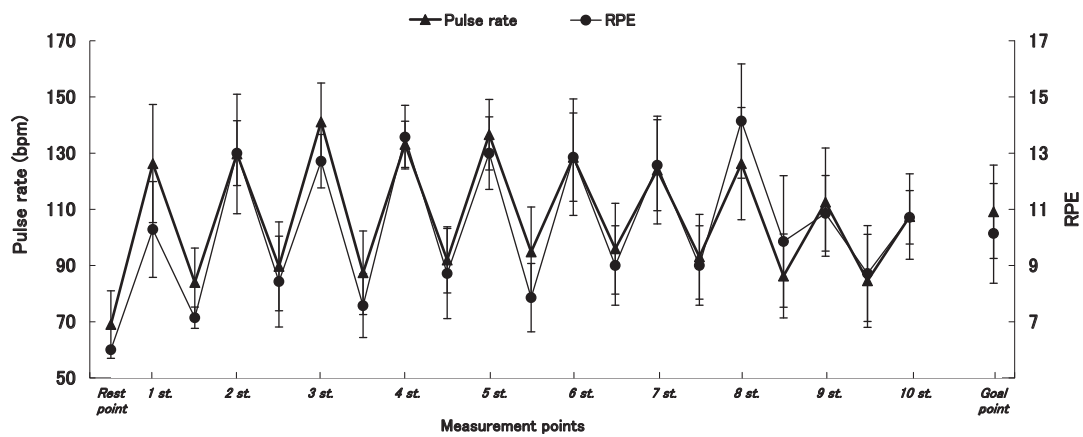


Fig. 1 Changes in pulse rate and RPE while climbing Mt. Daisen

Rest point vs. each station soon after subjects' arrival ($p < 0.01$), departure from each station ($p < 0.05$)
 each station soon after subjects' arrival vs. departure from each station ($p < 0.01$)

3. Changes of FVC, FEV₁, SpO₂ and the degree of dyspnea sensation

Figure 2 showed changes of FVC and FEV₁. There were no significant changes in FVC. FEV₁ at the summit (84 ± 11 %) was significantly (p<0.05) lower than at Ground (92 ± 5 %) and Rest point (91 ± 5 %). Figure 3 showed changes of SpO₂. No significant differences were found on SpO₂ at each measuring point. The degree of dyspnea sensation was shown in Figure 4. The degree of dyspnea sensation at each station soon after the subjects' arrival were significantly higher than those at the Rest point. Significant elevated degrees of dyspnea sensation were observed at each station soon after the subjects' arrival as compared with those before departure (p<0.05) outside of the 5th station. There were no significant differences between the Rest point and before departure at each station.

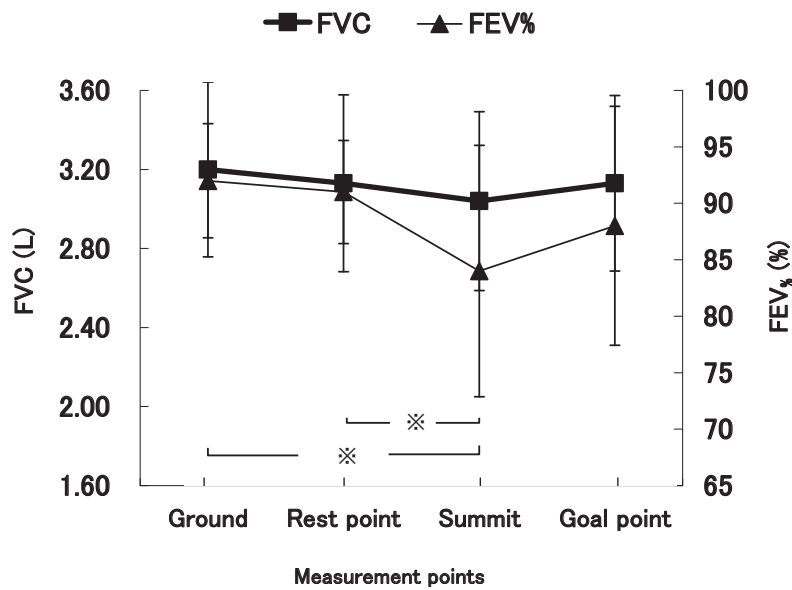


Fig. 2 Changes of FVC and FEV₁ while climbing Mt. Daisen

FEV₁: Summit vs. Ground, Rest point (p<0.05)

No significant differences were found in FVC at each measuring point

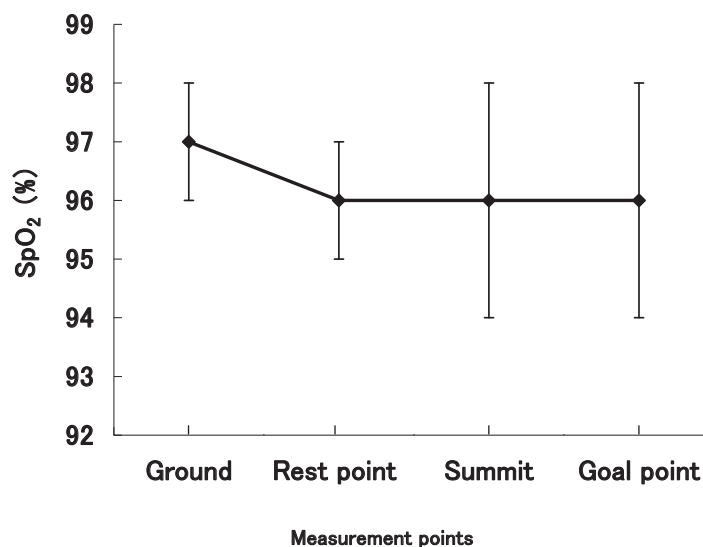


Fig. 3 Changes in SpO₂ while climbing Mt. Daisen

No significant differences were found in SpO₂ at each measuring point

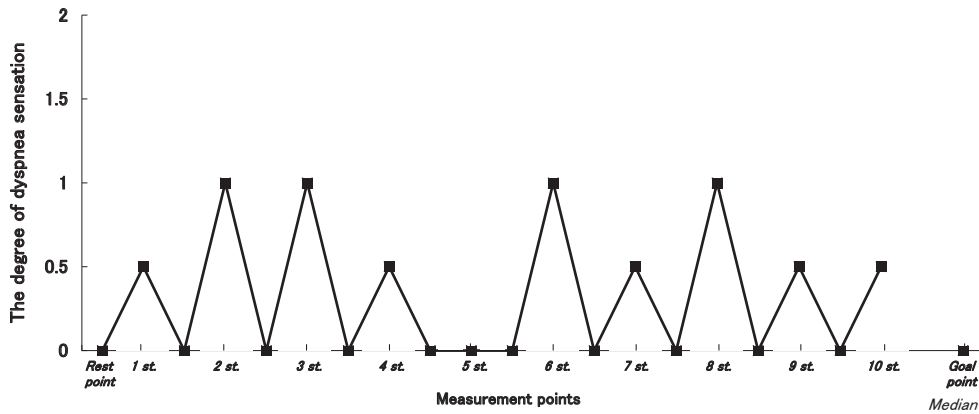


Fig. 4 Changes of the degree of dyspnea sensation while climbing Mt. Daisen

Rest point vs. each station soon after subjects' arrival ($p < 0.05$)

each station soon after subjects' arrival vs. departure from each station ($p < 0.05$: outside of 5th station)

Discussion

We examined changes of respiratory functions while climbing Mt. Daisen in the summer in young women. Based on the results, FEV% at the summit of Mt. Daisen significantly demonstrated lower readings than those found at Ground and Rest point.

Previous research about physiological responses in women while climbing mountains (changes of heart rate and oxygen [11-13], heart rate, blood pressure and arterial oxygen saturation at awakening and rest time in climbing Himalayas [14, 15] and changes of rectal temperature while ascending Mt. Daisen [13]) has been done. It was confirmed that the results of the index of exercise intensity in this study showed a similar level to the previous studies [11-13]. There is no research in young adult women, though previous studies [6, 7] targeted young adult men to investigate changes of respiratory functions (Peak Expiratory Flow) while climbing mountains. Recently, increased numbers of young women have been interested in mountaineering. Thus, it is important to examine respiratory changes in young women. Significant decreases of expiratory volume during ascending and return to the rest level during descending were found in this study. Our results were compatible with previous studies [6, 7]. We could not compare distal airway, because previous studies did not measure FEV% [6, 7].

SpO₂ at the Summit of Mt. Daisen was higher than prospective physiological stresses by indication of relationships between oxygen partial pressure and altitude [12]. However, FEV% at the Summit was significantly lower than the Ground and Rest point in this study. According to the previous research, discussions on ventilation volume with exercise intensity, and reduction of temperature, increases cold stimulation during ascending of mountains [4-7]. Therefore, it was considered that climbers might have acute spontaneous pneumothorax, pulmonary thromboembolic and airway obstruction under certain circumstances [4]. Pulse rate and RPE were at elevated volumes and it seems a great deal of mild dyspnea was observed at each station during the ascent of Mt. Daisen. The ascent of Mt. Daisen consisted of ten stat intervals (9 stations) in this study. Climbers received physiologically high exercise intensity in a slight change to low atmospheric pressure with elevation of altitude, and respiratory muscles demanded increased amounts oxygen. Thus, airway obstruction was set up and induced with increases in oxygen demand that led to increases of oral-breathing [6, 7]. For these reasons, it was considered that FEV% at the summit of Mt. Daisen significantly decreased.

As for respiratory functions, although there were no significant differences in FVC between the measured points, FEV% at the Summit significantly decreased. These data suggested that it was limited

in ventilation by resistance to airflow into and out of the lungs in spite of ample lung volume. Therefore, it seems that mild airway obstruction and increase of airway resistance occurred at the summit. It was clarified that respiratory functions were decreased as an acute stress on the respiratory system induced by increasing exercise intensity while ascending. On the other hand, respiratory functions at the Goal point returned to rest levels because the respiratory system's oxygen demand decreased while descending the mountain by changes on kinematic energy type [17]. Although the measured value of FEV₁% in this study was not at a noted level compared to the range of disease initiation risks for bronchial asthma and chronic obstructive pulmonary disease patients, FEV₁% at the Summit significantly decreased as compared with the Ground and Rest point. The results of this study indicated mild airway contraction induced by stresses on the respiratory system from increasing exercise intensity during an ascent of Mt. Daisen in summer. It is suggested that stresses on the respiratory system in mountain climbing under severe conditions such as high altitude and cold environment could be increased.

Conclusion

Mild airway contraction was confirmed in young women because of increased stresses on the respiratory system during an ascent of Mt. Daisen in summer.

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