

BRIEF REPORT

Effects of Hiking at Moderate and Low Altitude on Cardiovascular Parameters in Male Patients With Metabolic Syndrome: Austrian Moderate Altitude Study

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Objective.—Physical activity is a cornerstone in therapy for patients with metabolic syndrome. Walking and hiking in a mountain scenery represents an ideal approach to make them move. The Austrian Moderate Altitude Study (AMAS) 2000 main study is a randomized controlled trial to investigate the cardiovascular effects of hiking at moderate altitude on patients with metabolic syndrome compared with a control group at low altitude, to assess a potential altitude-specific effect.

Methods.—Seventy-one male patients with metabolic syndrome were randomly assigned to a moderate altitude group (at 1700 m), with 36 participants, or to a low altitude group (at 200 m), with 35 participants. The 3-week vacation program included 12 hiking tours (4 per week, average duration 2.5 hours, intensity 55% to 65% of heart rate maximum). Physical parameters, performance capacity, 24-hour blood pressure, and heart rate profiles were obtained before, during, and after the stay.

Results.—In both groups, we found a significant mean weight loss of -3.13 kg; changes in performance capacity were minor. Systolic, diastolic, and mean arterial pressures and circadian heart rate profiles were significantly reduced in both groups, with no differences between them. Consequently, the pressure-rate product was reduced as well. All study participants tolerated the vacation well without any adverse events.

Conclusions.—A 3-week hiking vacation at moderate or low altitude is safe for patients with metabolic syndrome and provides several improvements in their cardiovascular parameters. The cardiovascular benefits achieved are more likely to be the result of regular physical activity than the altitude-specific effect of a mountain environment.

Key words: hiking, moderate altitude, cardiovascular parameters, metabolic syndrome, Austrian Moderate Altitude Study

Introduction

Patients with metabolic syndrome are characterized by a cluster of cardiovascular risk factors, including central obesity, dyslipidemia, hyperglycemia, and arterial hypertension. Many etiological components of the metabolic syndrome derive from a sedentary lifestyle. Therefore, first-line treatment consists of a more active lifestyle, based on regular physical activity, and

restricted caloric intake.¹ Walking and hiking are sports activities of low to moderate intensity that can be performed even by patients with metabolic syndrome featuring obesity and poor cardiorespiratory fitness. Physicians should encourage these patients to be more active in both their daily life and during holidays. Walking and hiking in a mountain setting represents an ideal approach to enhance their physical activity. Although physical activity is proven to be beneficial, corresponding data assessing the cardiovascular effects of hiking are sparse for patients with metabolic syndrome.

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Thus, the project Austrian Moderate Altitude Study (AMAS) 2000 was initiated years ago. An initial pilot study demonstrated the beneficial effects of a hiking vacation at moderate altitude on metabolic parameters, namely, insulin resistance and lipid metabolism.² Thereafter, the AMAS-2000 main study, a randomized controlled trial including a control group at low altitude, was designed for distinguishing altitude-specific and exercise-induced effects. The metabolic results obtained from this study were published previously.³ Here, we present the cardiovascular effects of a 3-week hiking vacation at moderate altitude (1700 m) and at low altitude (200 m) on patients with metabolic syndrome. Owing to the potential influence of altitude, we expected different results between them.

Methods

STUDY PARTICIPANTS

Study participants were invited by a local newspaper and television report to take part in the Austrian Moderate Altitude Study. At the University Hospital in Innsbruck, 71 male nonsmoking subjects (median age 56 years, range 36–66) with metabolic syndrome according to the criteria of the Adult Treatment Panel III and the National Cholesterol Education Program were included in the study. The patients' medication was left unchanged during the whole vacation. The project AMAS-2000 was approved by the Ethics Committee of the Leopold-Franzens-University of Innsbruck. All participants gave written informed consent before the study.

Study participants ($n = 71$) were randomly assigned to a moderate altitude (MA) group (1700 m in Obertauern, Austria, $n = 36$) or to a sea level (SL) group (200 m in Bad Tatzmannsdorf, Austria, $n = 35$). Both groups were examined according to an identical time table.³ The baseline characteristics of the study participants are summarized in Table 1. In both groups, the 3-week vacation program was held in a comfortable resort hotel and included 12 moderate intensity hiking tours (4 tours per week and 3 rest days, mean duration of a tour approximately 2.5 hours, exercise intensity 55% to 65% of the individual heart rate maximum evaluated by the baseline stress test). Hiking tours were guided by health professionals in homogenous groups (7 to 10 persons), and moderate hiking intensity was individually controlled by heart rate monitoring. Both study groups had comparable and balanced nutrition. The average total caloric intake was calculated to be approximately 1800 kcal daily in both study groups. At several times, blood samples were taken and body weight, height, waist, and hip circumference were measured.³

Table 1. Baseline characteristics of the study participants

<i>Characteristics</i>	<i>MA group (n = 36)</i>	<i>SL group (n = 35)</i>
Age, years	55 ± 7	55 ± 8
Body mass index, kg/m ²	31.67 ± 3.35	31.19 ± 2.88
Waist circumference, cm	108 ± 9	105 ± 16
Waist-hip ratio	1 ± 0.1	1 ± 0.1
Fasting glucose, mg/dL	104 ± 11	104 ± 8
2-hour OGTT, mg/dL	114 ± 38	106 ± 29
Serum cholesterol, mg/dL	218 ± 34	198 ± 33
Serum LDL-C, mg/dL	131 ± 29	119 ± 30
Serum HDL-C, mg/dL	48 ± 13	46 ± 12
Serum triglycerides, mg/dL	193 ± 88	177 ± 90

Values are means ± SD (no significant differences between groups). MA, moderate altitude; SL, sea level; OGTT, oral glucose tolerance test; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

ERGOMETRY

An incremental 25 W, 2-minute symptom-limited maximal exercise test was performed on a cycle ergometer ER 800 (Ergoline, Bitz, Germany) 10 to 14 days before the hiking vacation and 7 to 10 days and 6 to 8 weeks after the vacation.

AMBULATORY BLOOD PRESSURE MONITORING AND 24-HOUR ELECTROCARDIOGRAPHY

All patients underwent ambulatory blood pressure monitoring (Mobil-O-Graph, IEM, Sheffield, UK) and 24-hour electrocardiography (Delmar Model 363, Digital-recorder 483, Fountain Valley, GA) on the first or second day and on the last 2 days of their 3-week vacation. By ambulatory blood pressure monitoring, systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial BP were recorded every 15 minutes during the daytime and every 30 minutes during the night. From the 24-hour electrocardiography we studied heart rate (HR), the number of ventricular premature beats, ST-segment changes, and episodes of bradycardia defined as HR less than 50 beats/min. The pressure-rate product (PRP [= SBP × HR]) was calculated afterward.

STATISTICS

A repeated measures analysis of variance was applied for the analysis of time dependence and group differences. Tukey's post hoc test was used for intergroup comparisons at the individual time points. Arithmetic means and standard deviations are presented for descriptive analysis. For absolute and relative performance capacity and laboratory parameters, paired and unpaired Wilcoxon

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