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Effects of a One-week Vacation with Various Activity Programs on Metabolism and Adipokines

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ABSTRACT

This study was conducted as part of a larger study of East Tyrolean health tourism, and investigates the effects of an active seven-day vacation on metabolic parameters and adipokines. Fifty-two healthy vacationers participated in two types of vacation activities (golf vs. Nordic walking or e-biking [NW&EB]). In the former group, 30 subjects played golf for a mean duration of 33.5 h per week; in the NW&EB group, 22 persons performed Nordic walking or e-biking for a mean duration of 14.2 h per week. Metabolic parameters and adipokines, such as leptin, adiponectin, GF-21, irisin, omentin-1, betatrophin, and resistin, were measured one day before and one day after the stay. After one week, only the NW&EB group experienced a significant decrease of 1.0 kg in body weight. Significant changes in HDL-C, FGF-21, irisin, and omentin-1 were seen in the golf group; and in triglycerides, HbA1c, leptin and adiponectin in the NW&EB group. No significant changes in betatrophin or resistin were registered in either group. A seven-day vacation with an activity program for several hours per week causes favorable changes in metabolic parameters and adipokines known to be involved in the pathophysiology of the metabolic syndrome. The changes differed in their magnitude and significance, depending on the type of activity.

Introduction

The effort recovery theory implies that chronic load at work may develop into pathological conditions when recovery during leisure time is incomplete [1]. Vacation is an essential form of recovery that workers need in order to recuperate from the strain of their workaday lives [2]. To what extent the duration of a vacation and the activities therein have an impact on recovery and health remains unclear, because scientific data on the subject are scarce. A vacation with an activity program might accelerate the recovery process and enhance the potential health effects of a short-term vacation.

Recently, we published the results of the cardiovascular part of the East Tyrolean health tourism study initiated in 2013 by the Tyrolean government. The study demonstrated beneficial cardiovascular effects after just one week of active vacation; the effects included significant reductions in blood pressure and heart rate, and improved cardiac diastolic function in healthy vacationers [3].

The present part of the East Tyrolean health tourism study was conducted in the same cohort, and is focused on the effects of a seven-day vacation with different activity programs on various metabolic parameters and adipokines. We assumed that the cardiovascular benefits described in the cardiovascular part of the study might have been mediated by an exercise-induced alteration of adipokines. Our understanding of the physiology of adipose tissue has changed significantly over the last two decades. Rather than being viewed as a site of inert energy storage, adipose tissue is now regarded as an active endocrine organ. Adipose tissue releases a cluster of inflammatory and anti-inflammatory adipokines which, in the pathological state of the metabolic syndrome, induce chronic inflammation, insulin resistance, dysregulation of appetite, and obesity. These culminate in the final complication, which is cardiovascular disease [4].

A large body of evidence has shown that physical activity improves cardiometabolic health, and aerobic exercise may modulate the profile of the adipokine pattern [5, 6]. The aim of this open comparative study was to investigate the exercise-related impact of a seven-day vacation with different activities on metabolic parameters and adipokines.

Materials and Methods

Study participants

Fifty-two healthy vacationers spent seven days at one of eight hotels in East Tyrol (670 – 980 meters above sea level) and participated in the study. The East Tyrolean health tourism study was approved by the ethics committee of Leopold Franzens University in Innsbruck, and met the ethical standards of the journal [7]. All participants provided their written informed consent prior to the study.

Three activity programs were available: golf, Nordic walking and e-biking. The participants were divided into two groups. The first was the golf group (n = 30), and the second group consisted of participants who did Nordic walking or e-biking (nw&eb group, n = 22). Nordic walking and e-biking were grouped together because both are aerobic forms of exercise, similar in terms of duration, intensity and energy expenditure. Assignment to the groups was based on the vacationer's preference. Activities were performed daily for six of seven days. Participants were free to take a day off during the week. Members of the golf group played golf on average 33.5 h per week while members of the NW&EB group exercised on average 14.2 h per week, performing six Nordic walking or e-biking tours (the mean duration of a tour was ~2.4 h) guided by fitness instructors. There were no dietary targets and no individual measurements of caloric or alcohol intake. The participants were at liberty to eat what they wished to, in accordance with their eating habits and the menu of the hotel.

Metabolic parameters

Blood specimens were taken one day before and one day after the stay. All metabolic parameters were assessed by routine methods at the Hospital of Lienz. Adiponectin, leptin, apolipoprotein A1, interleukin 6, TNF-alpha (Research And Diagnostic Systems, Inc., Minneapolis, MN, USA) and irisin (BioVendor Research and Diagnostic Products, Czech Republic) were analyzed by the use of commercially available ELISA kits at the Department of Internal Medicine I, Gastroenterology, Hepatology, Endocrinology and Metabolism, Medical University of Innsbruck, and at the Molecular Biology Laboratory, Vorarlberg Institute for Vascular Investigation and Treatment in Feldkirch, Austria (FGF-21 RD191108200R, Omentin-1 RD191100200R, Resistin RD191016100, Betatrophin RD191347200R from BioVendor Research and Diagnostic Products, Czech Republic).

Cardiovascular parameters

Several cardiovascular parameters and cardiac blood markers were analyzed, as published previously [3].

Statistics

Analyses were performed with the SPSS software package (version 9.0; Chicago, IL, USA) and IBM SPSS Statistics (Version 24, Armonk, N.Y., USA). Results are expressed as medians with interquartile ranges. Baseline characteristics of the study population were compared using the Mann-Whitney U test. Metabolic parameters and adipokines were analyzed for their distribution using histograms, qq-plots, boxplots, and the Shapiro-Wilk test. Normally distributed metabolic parameters and adipokines were compared using the paired *t*-test; non-normal data were analyzed with the Wilcoxon signed-rank test. The level of statistical significance was set to $p < 0.05$.

Results

Study participants

The study population consisted of 30 men and 22 women. The two groups comprised 30 golfers, and 22 persons in the combined Nordic walking (n = 11) and e-biking group (n = 11). The mean age of the participants was 54.3 years; baseline characteristics are summarized in ▶ **Table 1**. No significant differences existed between the groups. Post-vacation, only the NW&EB group experienced a significant decrease of 1.0 kg in body weight (p = 0.03).

Metabolic parameters and adipokines

Data concerning metabolic parameters and adipokines are listed in ▶ **Table 2**. After one week, we noted significant changes in HDL-C, FGF-21, irisin and omentin-1 in the golf group; and triglycerides, HbA1c, leptin and adiponectin in the NW&EB group. In addition, the decrease in adiponectin (18 %) was significant in the entire cohort (p = 0.04; data not shown). In the NW&EB group, the decreases in triglycerides, HbA1c and leptin were 33 % (p = 0.011), 6 % (p = 0.01), and 19 % (p = 0.03), respectively. Significant reductions in triglycerides (− 20 %; p = 0.02; data not shown) and HbA1c (− 4 %; p = 0.009) were noted in the entire cohort. FGF-21 levels fell in both subgroups; a significant difference was noted in the entire cohort (− 24 %; p = 0.002; data not shown) and the golf group (− 29 %; p = 0.005). The increase in irisin after the vacation was small, and significant only in the golf group (+ 6 %; p = 0.02) whereas the

▶ **Table 1** Baseline characteristics of the study population.

Demographics	Golf group (N = 30)	NW&EB group (N = 22)	P value
Age (years)	54 (47; 63)	58 (46; 61)	Ns
Sex (male)	53 %	64 %	ns
Body weight pre-vacation (kg)	83 (71; 96)	86 (62; 104)	ns
Body weight post-vacation (kg)	83 (71; 94)	85 (62; 104)	0.03
Body mass index (kg/m²)	26 (23; 30)	26 (22; 34)	ns
Body fat (%)	24.5 (20.5; 35.8)	25.4 (17.5; 37.6)	ns
Exercise duration (mean hours)	33.5	14.2	< 0.001

Results are expressed as medians with interquartile ranges; ns = non-significant.

▶ **Table 2** Metabolic parameters and adipokines in the golf group and the Nordic walking plus e-biking group (NW&EB group) one day before and after the vacation.

	Golf group		NW&EB group	
Parameters	**Before vacation**	**After vacation**	**Before vacation**	**After vacation**
Leucocytes (10^9/l)	5.75 (4.95 – 6.45)	5.75 (5.00 – 6.78)	6,15 (5.03 – 7.03)	5,80 (4.83 – 6.88)
hsCRP (mg/dl)	0.12 (0.06 – 0.34)	0,27 (0.07 – 0.41) *	0.12 (0.07 – 0.18)	0.15 (0.08 – 6.88)
IL-6 (ng/l)	2.1 (1.5 – 2.7)	2.1 (1.5 – 3.1)	1.7 (1.5 – 2.6)	1.5 (1.5 – 2.0)
LDL-C (mg/dl)	130 (107 – 146)	128 (118 – 151)	127 (97 – 155)	134 (91 – 153)
HDL-C (mg/dl)	55 (43 – 71)	60 (43 – 76) *	59 (40 – 70)	59 (41 – 75)
ApoA1 (mg/dl)	261 (226 – 312)	261 (215 – 346)	264 (223 – 305)	241 (53 – 228)
TG (mg/dl)	90 (58 – 147)	81 (61 – 117)	120 (82 – 159)	80 (65 – 134) *
Glucose (mg/dl)	94 (86 – 99)	94 (90 – 101)	93 (85 – 111)	88 (85 – 105)
HbA1c (%)	5.6 (5.4 – 6.0)	5.6 (5.3 – 6.0)	5.4 (4.9 – 5.8)	5.1 (4.8 – 5.6) *
HOMA-IR	1.31 (0.81 – 2.12)	1.21 (0.94 – 2.06)	1.50 (1.09 – 3.32)	1.62 (1.00 – 2.76)
Leptin (µg/l)	9.44 (5.94 – 18.05)	9.71 (5.54 – 14.56)	11.55 (4.98 – 16.63)	7.76 (4.59 – 13.11) *
Adiponectin (ng/ml)	9888 (6729 – 11483)	6829 (4698 – 11386)	7669 (5703 – 12339)	7547 (4203 – 10695) *
FGF-21 (pg/ml)	221 (158 – 342)	156 (90 – 223)***	194 (105 – 290)	149 (106 – 227)
Irisin (µg/ml)	3.31 (3.02 – 3.99)	3.40 (2.64 – 4.36) *	3.06 (2.49 – 3.91)	3.10 (2.81 – 3.87)
Omentin-1 (ng/ml)	717 (577 – 919)	796 (652 – 945)**	788 (639 – 937)	826 (713 – 955)
β-Trophin (ng/ml)	8.66 (5.85 – 14.21)	8.43 (7.17 – 10.2)	8.43 (5.0 – 14.2)	6.99 (5.77 – 9.46)
Resistin (ng/ml)	3.56 (2.63 – 4.04)	3.75 (2.97 – 4.13)	3.30 (2.58 – 3.69)	2.96 (2.24 – 3.69)

Results are expressed as medians with interquartile ranges; Within the group: vs. before vacation * = $p<0.05$; vs. before vacation ** = $p<0.01$; vs. before vacation *** = $p<0.005$.

increases in omentin-1 were considerable and significant in the entire cohort (+11%; p = 0.004; data not shown) and the golf group (+10%; p = 0.01). Exercise had no effect on levels of ApoA1, IL6, betatrophin or resistin.

Cardiovascular parameters

Cardiovascular parameters of the East Tyrolean health tourism study have been published previously [3]. In the golf group, the reductions in resting systolic and diastolic blood pressure (−11.0 mmHg; p = 0.01; −5.0 mmHg; p = 0.01, respectively) and resting heart rate were significant (p = 0.005). The same was true of blood pressure (p = 0.01) and heart rate (p = 0.01) at 100 watts during the incremental 25-W/2-min symptom-limited maximal exercise test.

Discussion

Regular physical exercise exerts several beneficial effects on metabolic disease, and is a meaningful lifestyle intervention for the effective prevention and treatment of numerous non-communicable diseases. Aerobic exercise enhances fat oxidation, lipoprotein profiles, glucose homeostasis, and insulin sensitivity. Playing golf, Nordic walking or e-biking are forms of aerobic exercise of low to moderate intensity, which makes them feasible for nearly everybody, including persons with poor cardiorespiratory fitness. Golf attracts about 80 million individuals worldwide and is considered very healthy in terms of reducing mortality and prolonging life by up to 5 years [8]. Nordic walking or hiking in mountainous areas are also very popular outdoor activities, feasible even for patients with metabolic syndrome, as shown in the AMAS 2000 study [9]. E-biking enables untrained persons to cycle up mountains and long distances on flat terrain by the use of a connectable electric motor. In our study, the participants were divided into a golf group and a NW&EB group because of the difference in exercise duration and intensity between the two groups. A golf stroke involves a great deal of dynamic and isometric muscle contractions when performing both, concentric and eccentric muscle actions. Apart from these aspects, golf is characterized by significantly lower exercise intensity and energy demands (3-4 METs) compared to Nordic walking or e-biking. The latter two sports are similar in terms of exercise duration and intensity (5-6 METs) [10].

Fat oxidation and glucose metabolism are affected by the energy expenditure resulting from the duration and intensity of exercise [11, 12]. During moderate-intensity exercise, adipose tissue provides most of the energy for working skeletal muscles through the mobilization of stored triacylglycerol. In the NW&EB group, which experienced a marked weight loss of 1.0 kg, we noted significant reductions in triglycerides, HbA1c and fasting glucose, which was indicative of improved fat and glucose metabolism. In the golf group we observed no change in glucose metabolism, but did register lower triglyceride levels. As exercise intensity is known to be one of the most important factors involved in substrate utilization, we assume that the putative discrepancy in glucose metabolism between the groups is due to weight loss and the higher exercise intensity of hiking and biking [11, 12]. Our assumption is supported by Venables et al., who also showed that a training program of continuous low-intensity exercise can improve fat oxidation associated with enhanced insulin sensitivity in obese middle-aged men [11].

However, the duration of exercise is the most important determinant of increased HDL cholesterol levels [11]. The golf group, which exercised on average 33.5 h per week, experienced a significant increment of 5 mg/dl in HDL cholesterol levels; this was twofold higher than the mean net change of 2.5 mg/dl registered in a meta-analysis [13].

Exercise-related adipokine responses should generally be interpreted with caution. In addition to the exercise load, adipokine patterns are also affected by confounding variables such as nutritional status, inter-individual variability, and the time course of the physiological adipokine response [14–16]. Both the golf and the NW&EB groups showed notable reductions in their leptin levels (11 and 19 %, respectively). The difference was significant in the NW&EB group, as well as the entire cohort. Leptin is implicated in the regulation of food intake, energy expenditure, and whole-body energy balance. In energy-deficient states such as weight loss by high exercise volume, leptin levels may fall even before any loss in body fat mass occurs [17]. The decreased leptin levels registered in our study add substantially to the pre-existing notion that prolonged endurance exercise with substantial energy expenditure is needed to reduce circulating serum leptin levels [4, 18].

Adiponectin was the second adipokine that was reduced in both groups; the difference was significant in the NW&EB group and the entire cohort. Similar to exercise, adiponectin exerts several beneficial effects on glucose, lipid and free fatty acid metabolism. However, the impact of exercise on the expression of adiponectin remains somewhat controversial, depending on exercise protocols and the degree of insulin sensitivity [4]. The majority of studies suggest that long-term exercise for longer than two months, of enough exercise volume to reduce body weight and increase insulin sensitivity, will increase adiponectin levels [19]. In contrast to this long-term effect, short-term exercise does not increase adiponectin levels. The reduced adiponectin levels registered in the present study add to a limited body of data suggesting that adiponectin levels decrease after short-term exercise as well [19]. Further studies will be needed to investigate the roles of exercise intensity and duration, and determine whether high-volume exercise of moderate intensity with large caloric expenditure is able to reduce adiponectin levels temporarily, as observed in our cohort.

In the golf group, we noted significant changes in FGF-21. FGF-21 is more of a stress-induced than a classical exercise-induced adipo-myokine, because many triggers are responsible for its release into circulation [20, 21]. FGF-21 regulates glucose homeostasis and triglyceride utilization, and has been related to improved insulin resistance, weight loss, and the browning of white adipose tissue. Moreover, FGF-21 is activated and released under different stress conditions such as starvation, mitochondrial dysfunction, and cold stress. Vacation reduces stress in general. Sufficient sleep and abundant nutritious food accelerate regenerative effects, leading to a physiological state of physical and psychological well-being. This state of relaxed well-being might have been the reason for the fall in FGF-21 levels registered in the study. This thesis, however, needs to be investigated and proven in future studies.

Irisin was increased in both groups, but the increase was only significant in the golf group. Irisin exerts its action on white adipocytes, and stimulates the uncoupling of protein-1 expression and other brown-fat-like genes, thus inducing browning and thermogenesis of white adipose tissue. Collectively, these effects increase energy expenditure, reduce fat mass, and improve glucose homeostasis [22]. The reduction of fat mass and improved glucose homeostasis registered in the present study may be attributed partly to the moderate increase in irisin. This finding has been confirmed by former data showing that exercise induces an immediate rise in irisin, which nearly normalizes during the following 24 h [23].

In both groups, systemic levels of omentin-1 rose after seven days of active vacation, but like irisin the difference was only significant in the golf group and the entire cohort. Ometin-1 reduces insulin resistance and exerts several anti-inflammatory and atheroprotective effects [24]. Therefore, ometin-1 is regarded as a negative risk factor for cardiometabolic diseases. The expression of omentin-1 is reduced in pathological states, such as obesity, metabolic syndrome, diabetes, atherosclerotic, cardiovascular and other diseases [25]. The increase in ometin-1 levels (11 %) was nearly the same as the 10.4 % increase observed in obese women after six weeks of endurance training [26]. In overweight and obese men, the exercise-related augmentation of omentin-1 was even higher (about 25 %) after a longer training period of 12 weeks [27]. Omentin also causes the dilatation of blood vessels. The significant reduction of blood pressure observed in the golf group, as published previously, may have been co-induced by a rise in omentin-1 levels [3].

In conclusion, the data of the East Tyrolean health tourism study prove that a) an active vacation of seven days causes favorable changes in metabolic parameters and adipokines known to be involved in the pathophysiology of the metabolic syndrome, and b) both activity groups (golf versus Nordic walking and e-biking) revealed similar and significant changes in their adipokine profiles, although to a varying degree due to the different exercise modalities. A seven-day vacation with an activity program may be recommended as an excellent recovery program for cardiometabolic regeneration.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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