Atherosclerosis 212 (2010) 621–627

Contents lists available at ScienceDirect

Atherosclerosis

journal homepage: www.elsevier.com/locate/atherosclerosis

Vascular and metabolic effects of 12 days intensive walking to Santiago de Compostela

Remy H.H. Bemelmans [a], Blai Coll [b], Daniel R. Faber [a], Jan Westerink [a], Paulus P. Blommaert [a], Wilko Spiering [a], Frank L.J. Visseren [a,*]

[a] Department of Vascular Medicine, University Medical Center Utrecht, F.02.126, PO Box 85500, 3508 GA Utrecht, The Netherlands
[b] Department of Nephrology, University of Lleida, Avda. Rovira Roure 80, Lleida 25198, Spain

ARTICLE INFO

Article history:
Received 18 May 2010
Received in revised form 2 June 2010
Accepted 4 June 2010
Available online 11 June 2010

Keywords:
Endothelial function
Exercise
Cardiovascular risk factors
Pilgrimage

ABSTRACT

Objective: Physical exercise has multiple beneficial health effects. Yearly, over five million persons walk a pilgrimage in various parts of the World, and this number is increasing. Here we report the effects on vascular function and cardiovascular risk factors of a 12-day pilgrimage to Santiago de Compostela in Spain.

Methods: Twenty-nine healthy male and female subjects between 40 and 70 years were included in the intervention group. The intervention consisted of the last 280 km of the pilgrim route to Santiago de Compostela. Twenty-nine control subjects were age- and gender-matched. Measures of endothelial function, vascular stiffness, autonomic function, and cardiovascular risk factors were measured 2 months and 2 weeks before the pilgrimage and 2 weeks and 2 months afterwards. During the pilgrimage cardiovascular risk factors, including weight, lipids, glucose and blood pressure were measured every other day.

Results: The mean daily walking distance during the pilgrimage was 23.42 ± 0.80 km taking 5.39 ± 0.36 h/day. From start to end, HDL-cholesterol increased (0.20 ± 0.30 mmol/L; +15%), while LDL-cholesterol (-0.6 ± 0.6 mmol/L; −17%) and weight (-1.4 ± 1.8 kg; −2%) decreased. After an initial rise, blood pressure came back to baseline. Two months after the pilgrimage a 2.0 kg weight loss persisted compared to the controls. There was no change in any vascular function parameter compared to the controls.

Conclusion: Walking a pilgrimage immediately influences major cardiovascular risk factors as a consequence of (strenuous) exercise and, likely, dietary changes. Two months after the pilgrimage these changes came back to baseline, except for weight loss. There was no effect on vascular function.

1. Introduction

In the past, walking was an inevitable and natural part of daily life. In modern Western societies and in urban parts of developing countries, physical exercise is not a self-evident part of every day activities anymore. Exercise has an inverse dose–response relation with all-cause mortality and is related to a lower risk of cardiovascular disease and type 2 diabetes [1,2]. Therefore, physical exercise is widely recommended in guidelines for prevention of cardiovascular diseases [3].

The beneficial effects of exercise are caused by improvement of classical cardiovascular risk factors, partly caused by weight loss [4,5]. Exercise decreases blood pressure by lowering total peripheral resistance as a consequence of decreased sympathetic nerve activity and improved insulin sensitivity [6]. Serum triglycerides are decreased by up-regulated lipoprotein lipase activity as a result of exercise [4,7]. Exercise increases HDL-cholesterol (HDL-c) by delaying particle clearance, increased production of nascent HDL particles and higher cholesterol content per HDL particle [4,7,8]. Plasma LDL-cholesterol (LDL-c) levels are typically unaffected by exercise [4,5]. Furthermore, physical activity improves insulin sensitivity by increasing the amount of functional GLUT4 glucose transporters [6,9].

Evaluation of the metabolic effects of exercise often focuses on training programs using treadmills or controlled exercise intensity [4–6,8,9]. In these studies, exercise programs range from 3 weeks to 1 year with moderate intensity exercise during 1–5 h/week [4–6,8,9]. Some studies investigate special forms of exercise such as climbing the Mount Everest or running or cycling a marathon [7,10,11]. Furthermore, studies often report the immediate health effects of one exercise session [7,10], or long-term results of training programs [4,5,8,9].

People from various cultural and religious backgrounds walk parts of pilgrim routes at various places in the world. Walking

* Corresponding author. Tel.: +31 88 7555555; fax: +31 88 2505488.
E-mail address: F.L.J.Visseren@umcutrecht.nl (F.L.J. Visseren).

0021-9150/$ – see front matter © 2010 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.atherosclerosis.2010.06.012

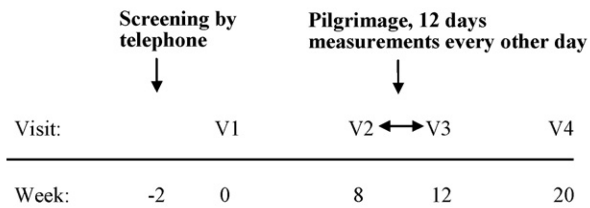

Fig. 1. Study design.

pilgrim routes is an ancient tradition, which is regaining popularity. It is estimated that over five million people walk pilgrim routes every year. For example, in 1984, 2491 people registered arrival on foot in Santiago de Compostela, Spain, and this number increased to almost 150,000 in 2009 [12]. In the present study, we investigated both the immediate and persisting effects of a 12-day pilgrimage, covering 280 km, to Santiago de Compostela, on cardiovascular risk factors and vascular function in healthy middle-aged male and female subjects already intending to walk this pilgrimage compared to healthy controls.

2. Subjects and methods

2.1. Subjects

The study was approved by the Medical Ethics Committee of the UMC Utrecht. All participants gave written informed consent before inclusion. Healthy male and female participants between 40 and 70 years of age were recruited by an announcement in the magazine of the Dutch Saint James Fellowship. The participants already intended to walk part of the Santiago de Compostela pilgrimage. Control subjects were physically capable of walking the pilgrimage but could not walk during the planned period due to logistical reasons and refrained from other types of strenuous exercise during the study. Controls were matched for age (±5 years) and gender to the subjects in the intervention group. Subjects diagnosed with diabetes mellitus, uncontrolled hypertension or a history of cardiovascular disease were excluded, as well as subjects using lipid lowering-medication.

2.2. Study design

This is a non-randomized intervention study with a control group. The intervention consisted of walking part of the Camino Francés, the classical pilgrimage route to Santiago de Compostela [13], from June 28th until July 10th 2009, covering 280 km, between Hospital de Órbigo and Santiago de Compostela. All participants visited the research unit of the department of Vascular Medicine of the UMC Utrecht 2 months and 2 weeks before the pilgrimage and 2 weeks and 2 months afterwards for measurements of cardiovascular risk factors and vascular function (Fig. 1). During the pilgrimage anthropometric and laboratory measurements in the intervention group were done every other day. In the analyses, three different periods are considered (Fig. 1): the pilgrimage (V3 minus V2), the total exercise period (preparation and pilgrimage; V3 minus V1) and the whole study period (V4 minus V1).

2.3. Measurements during clinic visits

Prior to all visits at the UMC Utrecht, the subjects fasted for 12 h, apart from drinking water, and refrained from smoking. All visits were planned during morning hours, for each individual at the same time as the preceding visit(s) to minimize within subject daytime-induced variation in vascular function.

2.3.1. Anthropometric measurements

During each visit blood pressure, pulse frequency, weight, waist- and hip-circumference were recorded. Blood pressure was calculated as the mean of three recordings in seated position using an automated blood pressure device (Omron 705 IT, Hoofddorp, The Netherlands).

2.3.2. Laboratory measurements

Fasting venous blood samples were collected for measurement of glucose, insulin, high-sensitivity C-reactive protein (hsCRP), total cholesterol, HDL-c, triglycerides (TG), and apolipoprotein B (ApoB) at each visit. At baseline thyroid stimulating hormone (TSH), aspartate aminotransferase (ASAT), alanine aminotransferase (ALAT), gamma-glutamyltransferase (γGT), creatinin, hemoglobin, leucocytes and platelets were determined. Homeostatic model assessment of insulin resistance (HOMA IR), body mass index (BMI) and LDL-c were calculated.

2.3.3. Endothelial function measurements

Flow-mediated dilatation (FMD) measures the increase in arterial diameter, a measure of endothelial function of conduit arteries, on reactive hyperaemia-induced shear stress. The procedure was conducted under standardized conditions. The brachial artery was visualized with a 5–14 MHz vascular transducer. After 1 min of baseline recording, blood flow was obstructed for 5 min by cuff inflation. After deflation, reactive hyperaemia occurred and three more minutes were recorded. The sonographer ensured the exact transducer position. Images were analyzed using Brachial Analyzer 5.8.3 (Medical Imaging Applications, Coralville, Iowa, USA). Brachial FMD was calculated as (maximal − baseline diameter/baseline diameter) × 100%.

Peripheral arterial tonometry (PAT) measures the increase in finger blood volume with tonometry on reactive hyperaemia-induced shear stress, a measure of endothelial function of small vessels and microcirculation. PAT was recorded simultaneously with FMD. The Endo-PAT2000 (Itamar Medical, Caesarea, Israel) was used, connected to a laptop with installed Endo-PAT2000 software. The PAT data were uploaded and analyzed by Itamar Medical Ltd. PAT results are expressed as reactive hyperemia index (RHI): (maximal − baseline arterial tone occluded arm)/(maximal − baseline arterial tone control arm).

To assess intra- and inter-observer agreement of the FMD analyses, a random sample (10 and 5%, respectively) of images was scored again by the same observer (R.B.) and by another observer, blinded to the first result. There was no significant difference between the first and second analysis of the same observer ($p = 0.58$) and between the different observers ($p = 0.11$). The intraclass correlation coefficients were 0.89 and 0.97, respectively, indicating good intra- and inter-observer agreement. Twenty-three FMD- and two PAT-measurements were of insufficient quality. These were replaced by measurements of the most nearby visit (both visits before or after the pilgrimage).

2.3.4. Heart rate variability (HRV), pulse wave analysis (PWA) and pulse wave velocity (PWV)

HRV measures the variability in R–R intervals on a continuous ECG, reflecting the balance between sympathetic and parasympathetic activation. PWA measures vascular stiffness (Augmentation Index) and central blood pressures, by analysing the peripheral pulse wave form, while PWV measures the velocity of pulse waves, another measure of vascular stiffness. HRV, PWA and PWV were recorded using the Sphygmocor® system (AtCor Medical, West Ryde, Australia). Subjects were in supine position when HRV was measured with a 3 ECG lead during 5 min. The pressure tonometer was used to record PWA at the right radial artery and PWV at the right carotid and radial artery.