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Effects of intermittent exercise on biomarkers of cardiovascular risk in night shift workers

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ABSTRACT

Objective: Cathepsin L (CatL), cathepsin S (CatS), and arteriosclerosis adhesion molecules such as monocyte chemotactic protein-1 (MCP-1), soluble vascular cell adhesion molecule-1 (sVCAM-1), and soluble E-selectin (sE-selectin) are potent elastases implicated in human arterial wall remodeling. In this study, we aimed to evaluate the effects of intermittent exercise on the plasma concentrations of these cathepsins and arteriosclerosis adhesion molecules in night shift workers.

Methods: Thirty male participants who were night shift workers (experimental group, $n = 15$; control group, $n = 15$) were included in this study. The experimental group performed an intermittent exercise at 10-min bouts (30 min per day), three days a week during 10 weeks. Body composition, blood pressure, and cardiovascular disease risk factors were measured.

Results: After intermittent exercise, significant group time interactions for body weight ($p < .01$) and body fat percentage ($p < .01$) were found. With regard to cardiovascular disease risk factors, group time interactions for CatL ($p < .01$), CatS ($p < .01$), MCP-1 ($p < .05$), sE-selectin ($p < .01$), and sVCAM-1 ($p < .01$) were significant.

Conclusions: This study provides preliminary evidence to suggest that intermittent exercise may represent an effective intervention strategy for preventing atherosclerosis, thus leading to improved cardiovascular health in night shift workers.

1. Introduction

Night-shift workers have a 67% higher prevalence of cardiovascular disease risk than those who perform their work activities during the day [1]. The exact mechanisms through which night-shift work causes cardiovascular disease are still not completely understood; however, it is thought that the main contributing factors include disturbed circadian rhythms and confounding factors such as smoking, poor eating habits, and social problems causing stress, which are common among night-shift workers [2].

Cathepsins (Cats) are located in lysosomes and endosomes, and their function is to degrade unwanted intracellular or endocytosed proteins. Recently, studies have discovered non-traditional roles for Cats in the extracellular space during the development and progression of cardiovascular disease [3]. Currently, 11 human cathepsins (B, C, H, F, K, L, O, S, V, W, and X) are known at the sequence level [4]. Cathepsin L (CatL), Cathepsin S (CatS), and Cathepsin K (CatK) release proteases to degrade extracellular collagen and elastin in the arterial wall, thus promoting atherogenesis [5]. Furthermore, cysteinyl Cats may have certain biological roles and molecular functions in vascular pathological processes, and may hence have potential application as diagnostic or prognostic markers [6]. Additionally, atherosclerotic lesions demonstrate an increased expression of chemokines such as chemotactic protein-1 (MCP-1), soluble vascular cell adhesion molecule-1 (sVCAM-1), and soluble E-selectin (sE-selectin) in endothelial cells of plaque

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microvessels or in endothelial cells overlying the lipid core—a response that may contribute to further leukocyte recruitment to sites of atherosclerosis [7]. Adhesion molecules (i.e., MCP-1, sVCAM-1, and sE-selectin) have emerged as particularly attractive candidates for the early adhesion of mononuclear leukocytes to the arterial endothelium at the site of atheroma initiation; moreover, this particular type of leukocyte has been reported to be found in a nascent atheroma [8].

Intermittent exercise within a short-term period has been shown to be effective in improving fitness and favorably altering several cardiovascular risk factors; moreover, the recommendation of continuous exercise has been primarily based on epidemiological evidence suggesting a response relationship between the amount of physical activity and health [9]. Additionally, short-term intermittent exercise has been shown to be as effective as continuous exercise for gaining health benefits, without the burden of adherence that accompanies continuous exercise. Moreover, no differences in the sleep–wake cycle have been found between night-shift workers and day workers [10]. Thus, short-term intermittent exercise might be an easier approach to physical activity or exercise during work time in night-shift workers.

In the present study, we aimed to investigate the effect of intermittent exercise on cardiovascular disease risk factors in night-shift workers. We hypothesized that regular intermittent exercise training would mediate the risk factors of cardiovascular disease in night-shift workers.

2. Methods

2.1. Study participation

Among the 50 male participants enrolled in the study, those with one or more of the following criteria were excluded: history of stroke, cardiovascular diseases, or hepatectomy (n = 7); history of hypertension (n = 5); history of diabetes (n = 6); and incomplete data on medical history (n = 2). The final study population included 30 men who were night-shift workers.

All the participants lived in the same dormitory, and maintained the same sleep–wake cycle during the study period. The participants were randomly assigned into the exercise group (n = 15) and control group (n = 15). Written informed consent was obtained from the study participants. The characteristics of the subject are shown in Table 1.

2.2. Measurement of body composition

Physical and anthropometric variables were measured at baseline and after 10 weeks in both groups. Body mass and height were measured to the nearest 0.1 kg and 0.1 cm, respectively, using a Venus 5.5 body composition analyzer (Jawon Medical, Gyeongsan, Korea). Body mass index was calculated as weight in kilograms divided by the square of the height in meters.

Table 1
The characteristics of the subject.

Variable	Group		
	NEG (n = 15)	NCG (n = 15)	*p*-value
Age (years)	56.80 ± 1.82	58.33 ± 1.88	0.062
Height (cm)	167.6 ± 2.98	170.7 ± 6.33	0.200
Weight (kg)	65.73 ± 3.91	68.08 ± 8.50	0.044
BMI (kg/m^2)	23.36 ± 1.42	23.32 ± 2.32	0.169
Fat free mass (kg)	15.05 ± 2.54	15.34 ± 4.32	0.183
Fat mass percent (%)	22.94 ± 2.63	22.19 ± 4.34	0.323
SBP (mmHg)	133.1 ± 4.33	131.5 ± 2.97	0.394
DBP (mmHg)	89.07 ± 4.46	85.47 ± 3.25	0.039
Duration of employment (years)	12.40 ± 3.96	10.00 ± 5.37	0.000
Duration of smoking (years)	17.00 ± 7.29	16.53 ± 7.29	0.819

Values are means ± SD. SBP; systolic blood pressure, DBP; diastolic blood pressure, BMI; body mass index, NEG; night shift worker exercise group, NCG; night shift worker control group, p-values were analyzed by unpaired t-test.

2.3. Intermittent exercise program

The 10-week exercise program intervention consisted of 3 days of walking exercise per week (i.e., Monday, Wednesday, and Friday). Based on the highest heart rate recorded during the VO_2max test, a target zone corresponding to 60–79% of the maximal heart rate was established for each subject. Although a consensual definition of moderate intensity physical activity is lacking, we choose the American College of Sports Medicine [11] classification since monitoring heart rate is much easier during an exercise program. Moreover, all the sessions were supervised by experienced trainers, and the first session was started during the night shift at 1800.

Participants were instructed to walk briskly, while maintaining their heart rate within the designated zone, on 3 days each week for 30 min/day; the accumulated 30 min of walking per day comprised three, 10-min sessions separated by intervals of ≥4 h. The exercise program was self-monitored, and participants were encouraged to schedule their walking time into their night routines while at work.

The target heart rate was continuously monitored using a Polar RS-400 heart rate monitor (Polar Elector Co., Kempele, Finland).

2.4. Blood collection and laboratory assays

Fasting venous blood samples were collected from all participants at baseline and at 10 weeks. Fasting was maintained for 12 h, and blood samples were collected on the following day. Enough sleep and the radical movement as much as possible to refrain. The blood sample protocol described by Pimenta et al. [12] was used in the present study. All samples were taken at 0830 AM from an antecubital vein. Serum samples were obtained after centrifugation and stored at −80 °C. Serum levels of CatL, CatS, CatK, MCP-1, sE-selectin, and sVCAM-1 were determined enzymatically using standard laboratory procedures. The serum levels of these cathepsins and adhesion molecules in the blood samples were measured using sandwich-type enzyme-linked immunosorbent assay Dueset kits (R&D systems, Minneapolis, MN, USA) according to the manufacturer's instructions, as described previously.

2.5. Statistical analysis

All results were reported as the mean ± standard deviation. All data were analyzed using SPSS version 19.0 (SPSS Inc., Chicago, IL, USA). First, we used and independent samples t-test to assess group differences at the baseline variables. We also used multivariable adjusted analysis of covariance (ANCOVA) to determine interaction (group × time) effects for all outcome variables, adjusted for age, body mass index (BMI), duration of employment, and smoking habits. Statistical significance was accepted at the 0.05 level. All variables are presented as the means ± standard deviations.

3. Results

All participants in the exercise group attended each exercise session, and none of the participants dropped out in a intervention. Body composition and biomarkers of cardiovascular risk measured at baseline and after 10 weeks are presented in Table 2 and Table 3. ANCOVA revealed group × time interactions for weight ($p < .01$), fat mass ($p < .01$), and percentage of fat ($p < .01$). Within-group analyses showed that weight measured at 10 weeks was significantly