Physical activity, cardiorespiratory fitness and carotid intima thickness: sedentary occupation as risk factor for atherosclerosis and obesity

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Abstract. – OBJECTIVE: The influence of occupational physical activity on markers of atherosclerosis, prevalence of metabolic syndrome and physical performance has been understudied in current literature. Main aim of this study was to examine the association between physical work environment and physiological performance measures, physical activity, metabolic parameters and carotid atherosclerosis among German career firefighters and sedentary clerks.

PATIENTS AND METHODS: We prospectively examined and recruited 143 male German civil servants (97 firefighters [FFs], and 46 sedentary clerks [SCs]). Correlation for each parameter for the groups were compared using a linear regression model adjusted for age.

RESULTS: 97 firefighters (FFs) showed higher maximal aerobic power (VO_{2max}) of 3.17 ± 0.44 L/min compared to 46 sedentary clerks (SCs) 2.85 ± 0.52 L/min (-0.21 CI -0.39-0.04, *p* = 0.018). Physical activity (PA, in METS/week) in FFs was 3953 ± 2688 and in SC 2212 ± 2293 (-1791.86 CI -2650--934, *p* = 0.000). Body fat was 17.7 ± 6.2% in FFs and in SCs 20.8 ± 6.5% (1.98 CI -0.28-4.25, *p* = 0.086). Waist circumference was 89.8 ±10.0 cm in FFs and in SCs 97.3 ± 11.7 (-4.89 CI 1.24-8.55, *p* = 0.009). Carotid intima media thickness (IMT) showed significant difference for the left carotid artery 0.69 ± 0.19 mm in FFs vs. SCs 0.81 ± 0.20 (0.07 CI 0.01-0.14, *p* = 0.030). Metabolic syndrome was found in 12 out of 98 FFs (13.4%), and in 14 out of 46 SCs (30.43%).

CONCLUSIONS: FFs showed significantly higher physical activity levels compared with the SCs. SCs had higher cardiovascular risk profile, higher prevalence of metabolic syndrome, higher waist circumference and significantly higher IMT than FFs. In conclusion, sedentary occupations have higher cardiovascular risk secondary to accelerated atherosclerosis.

Key Words:
Carotid atherosclerosis, Cardiorespiratory fitness, Firefighters, Sedentary clerks, Occupational health.

Abbreviations

BMI = body mass index (kg/m^2); BSA: body surface area (m^2); BSA = Sqrt (cm × kg)/3600); CHD = coronary heart disease; CI: confidence interval (95%); FFs = firefighters; HBA1c = glycated hemoglobin: HR_{max} = maximum heart rate; HR_{RCP} = heart rate at respiratory compensation point; LP(a) = Lipoprotein (a); METS = metabolic equivalents; n = number of participants; RCP = respiratory compensation point: Relative = absolute value in ml/kg^{-1} · min^{-1}; SCs = sedentary clerks; SD = standard deviation; VO_{2max} = maximum oxygen uptake (L/min); VO_{2AT} = oxygen uptake at aerobic threshold (L/min); VO_{2RCP} = oxygen uptake at respiratory compensation point; W_{max} = maximum power in Watt (Joule/s); W_{max}/kg = Maximum power/kg.

Introduction

Physical inactivity is the biggest public health problem of the 21st century[1]. Sedentary behavior and low physical activity leads to negative telomere length changes[2] and increased intima thickness of carotid artery in connection to metabolic syndrome[3]. Physical inactivity is thought to be responsible in up to 25% of all cases for the development of breast- and colorectal cancer, up to 27% for the development of diabetes mellitus, and up to 30% for the development of ischemic coronary heart disease[4]. Social network is linked to prognosis[5] and health-related behavior has in-

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fluence on individual vulnerability to diseases[6]. Civil servants have different health inequalities[7]. Sitting in an occupational context (e.g. sedentary clerks) can be linked for people in full-time employment to an average of 26-45.2 hours/week[8]. Heart disease causes 45% of the deaths that occur among U.S. firefighters while they are on duty[9]. Cardiorespiratory fitness is a strong independent mortality predictor. It is a reliable objective marker of habitual physical activity and a significant diagnostic and prognostic clinical indicator[10]. Association of higher physical activity with positive changes of metabolic risk parameters is a known phenomenon[11,12]. The role of psychosocial factors in the development, management, and prognosis of cardiovascular disease is an area of increasing interest. The goal of promoting well-being at work is not new, it has been the purpose of the occupational health movement since late 1960s[13]. Physically hard working environment had positive influence on mortality in the fifties[14]. Social circumstances at work showed an inverse association between social class, as assessed by grade of employment, and mortality from a wide range of diseases[7].

Patients and Methods

Study Population

This study was designed to investigate the fitness level, physical activity and cardiovascular risk factors of professional firefighters in comparison with sedentary clerks. One of the main focuses in this study was to examine the group differences and not to measure the absolute values in a given occupational group. We aimed to investigate the impact of physical activity on the extent of atherosclerosis. Sedentary clerks are civil servants, who predominantly work “as white collar workers” in tax office or municipal administration in a sitting position. All participants were invited via the internet, the social media and the local corporate distribution. In our study, metabolic syndrome was defined as per already published criteria by Alberti et al[15].

Data Collection

Maximal aerobic power (VO_{2max})[16,17] and aerobic capacity[18] (relative VO_{2max} ml/kg^{-1} ·min^{-1}) at the aerobic threshold were estimated using the spiroergometry. Physical activity was measured in vigorous METS (jogging, cycling, swimming, football, martial arts sport, strength training) according to the “*Compendium of Physical Activities*”[19] to estimate the differences of energy consumption in the different groups of civil servants. Cardiovascular risks and metabolism were measured by cholesterol and triglyceride values, glycated hemoglobin and homocysteine or lipoprotein(a). All examinations were performed according to the prescribed recommendations[20,21].

All examinations were performed from 1st January 2014 up to 15th June 2014 at the Sports Medicine Center, Hagen (Research Sector Prevention, Public Health and Sports Medicine, University Witten-Herdecke, Germany). The protocol for spiroergometry[16-18] involved the following: the stress test was conducted after successful gas and volume calibration. It was started at 50 Watt and then increased in steps of 25 Watt every 2 minutes (Ramp-test). The test ended when the subject could no longer maintain the predefined cadence of 80/min or if the subject was subjectively exhausted and there was no further increase in VO_{2max} after 20 seconds. Spiroergometric analyses were conducted according to published literature[16,18]. VAT (ventilator aerobic threshold) was determined as the first non-linear increase in the ventilatory equivalent for oxygen without a simultaneous increase of the ventilatory equivalent for CO_2. Respiratory compensation point (RCP) was determined as a simultaneous non-linear increase of both ventilatory equivalents according to the recommendations[16-18]. Body weight and body composition were determined using Tanita BC-418MA segmental body composition analyzer[22]. Subjects were instructed to wear only comfortable shorts without any other clothes. A validated questionnaire according to Ainsworth et al[19] was used to calculate the weekly reached global METS values.

Ethics Statement

All participants gave verbal and written consent to voluntary performance testing and for use of their data in this research study. All data were anonymized. The study was approved as a doctoral dissertation by the Dissertation Audit Committee of the University Witten/Herdecke, Hagen, Germany. Additionally, approval by an Ethics Committee was given 2013 (no 121/2013). This study did not introduce any pharmaceutical interventions or changes in the clinical course of the participants. In cases of incidental findings of clinical illness a medical report was sent to the family doctor.

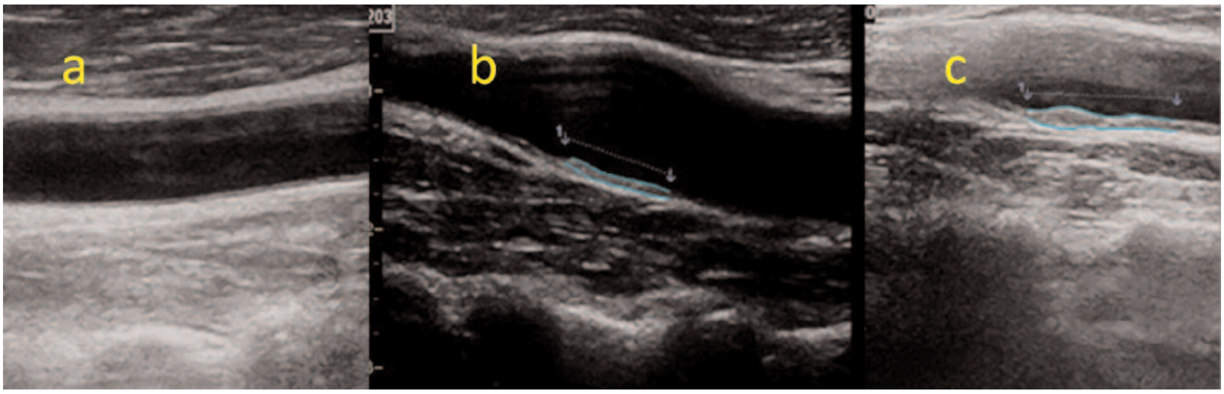

Figure 1. ***A***, normal carotid intima; ***B***, automatic measurement of intima thickness; ***C***, increased carotid intima thickness.

Assessment of Carotid Atherosclerosis and Intima Thickness

Measurements of carotid intima thickness (IMT) were taken along a 1.0- to 1.5-cm section of both the left and right common carotid artery below the carotid bulb using high-resolution B-mode ultrasonography (Figure 1). Automatic border detection technique of the VIVID 9 (VividE9, GE-Healthcare, Horten, Norway) ultrasound system was used. An average value was estimated by the system. Additionally, a maximal value of the intima thickness was manually estimated by experienced investigator. Measurements were made with the participants supine and the image focused on the posterior wall[23].

Statistical Analysis

Data are described separately for two groups. Anthropometric parameters, clinical characteristics, parameters of physical activity and cardiorespiratory fitness were described by mean, standard deviation, minimum and maximum. Differences between groups were estimated by linear regression adjusted for age since most of the analyzed parameters are directly age-related and 95% confidence interval (CI).

All statistical tests were two sided at a significance level of 0.05. Because of the exploratory character of the study, *p*-values were not adjusted for multiple testing. Stata/IC 13.1 for Windows was used for statistical analysis.

Results

Participants Characteristics

In this prospective study all 143 consecutively recruited male participants were included in the study. We examined 143 German servants (97 career firefighters and 46 sedentary clerks).

Clinical characteristics (heart rate, arterial blood pressure) and anthropometric data are shown in Table I (all statistic comparisons between both groups are age adjusted). None of the volunteers had a history of stroke or coronary disease and all participants could be considered as healthy. Sedentary clerks were older, therefore an age-adjusted analysis was performed to reduce bias to minimum. Firefighters were thinner than sedentary clerks: waist circumference in FFs was 89.8 cm ± 10.0, estimated difference versus SCs was 4.89 (CI 1.24-8.55, $p = 0.009$). Body fat in % was lower in FFs compared to SCs, but without significance (1.98, CI -0.29-4.25, $p = 0.086$). Muscle body mass was similar in both groups.

Physical Activity

Physical activity was estimated in METS (metabolic equivalents) according to Ainsworth et al[19]. Regarding the possible errors and pitfalls[24-26] we used only vigorous METS (football, martial arts sport, strength training, jogging, swimming, cycling). Sleeping, sitting, car driving and standing were not taken into account. FFs were more active than SCs, because on duty firefighters have more opportunity for training when they are waiting for assignment. FFs have corporate sports programs. Cardiac negative remodeling was not found[27]. All results of physical activity in METS are shown in Table II.

Cardiorespiratory Fitness

Only VO_{2max} as absolute value was significantly higher in FFs (3.17±0.44 L/min) when com-

Table I. Anthropometry: description and estimated group differences (linear regression adjusted for age).

Parameters	FF number mean (SD)	SC number mean (SD)	SC vs FF, CI difference CI *p*-value
Age	n=97 40.5 (9.0)	46 45.8 (10)	5.30 (1.86-8.74) $p = 0.003$
Weight in kg	n=97 85.9 (11.5)	n=46 87.1 (13.4)	0.13 (-4.38-4.64) $p = 0.995$
Height in cm	n=97 182.2 (6.3)	n=46 181.5 -0.10	(5.4) (-2.12-1.93) $p = 0.835$
BMI	n=97 25.9 (3.2)	n=46 26.4 (4.1)	0.08 (-1.22-1.38) p=0.904
BSA	n=97 2.08 (0.16)	n=46 2.09 (0.17)	-0.00 (-0.06-0.06) $p = 0.999$
Muscle mass in kg	n=97 67.1 (6.9)	n=46 65.3 (6.4)	-1.72 (-4.15-0.70) $p = 0.162$
% Body fat	n=97 17.7 (6.2)	n=46 20.8 (6.5)	2.05 (-0.23-4.33) $p = 0.078$
Waist in cm	n=97 89.8 (10.0)	n=46 97.3 (11.7)	4.89 (1.24-8.55) $p = 0.009$
Heart raterest	n=97 67.6 (12.0)	n=46 70.1 (12.5)	2.09 (-2.48-6.65) $p = 0.367$
BP systole at rest mmHg	n=97 126.4 (9.8)	n=46 129.1 (11.7)	2.19 (-1.81-6.19) $p = 0.281$
BP diastole at rest mmHg	n=97 84.1 (7.4)	n=46 86.6 (8.7)	1.55 (-1.34-4.44) $p = 0.292$
Cigarettes/day	n=97 2.57 (6.26)	n=46 1.72 (5.53)	-1.27 (-3.31-0.76) $p = 0.219$

BMI = body mass index; BP = blood pressure BSA = body surface area; CI = confidence interval (95%); FF = firefighters; n = number of participants; SC = sedentary clerks; SD = standard deviation; mean = mean value.

pared to SCs 2.85±0.52 L/min (-0.21 CI -0.39-0.04, $p = 0.018$). Relative VO_{2max} ml/kg^{-1} ·min^{-1} was similar in both groups. Aerobic capacity (VO_{2AT}) was not different in both groups. Maximal power (W_{max}) was significant higher in FFs than in SCs (-32.07 CI -47.9-16.2, $p = 0.004$). After weight adjustment (W_{max}/kg) FFs were stronger than SCs 3.03±0.74 W/kg (-0.36 CI 0.60-0.12, $p = 0.004$). All results are shown in Table III. Maximal METS during exercise were similar in both groups.

Carotid Atherosclerosis

Automatic border detection technique showed a significant age adjusted difference from 0.07 mm (CI 0.01-0.14, $p = 0.030$) for the left carotid intima thickness (Table IV). All other measure-

Table II. Physical activity: description and estimated group differences (linear regression adjusted for age).

Physical activity	FF n mean (SD)	SC n mean (SD)	SC vs. FF, CI difference CI *p*-value
Leisure time sport h/week	n=97 6.0 (3.6)	n=46 4.03 (3.02)	-1.79 (-2.96--0.63) $p = 0.003$
Corporate sport h/week	n=97 1.50 (1.52)	n=46 0.15 (0.63)	-1.22 (-1.59--0.86) $p = 0.000$
Strength training h/week	n=92 1.73 (1.81)	n=46 0.71 (1.27)	-0.82 (-1.34--0.24) $p = 0.005$
Strength training METS/week	n=92 804 (836)	n=46 363.1 (652.1)	-362.74 (-635--91) $p = 0.009$
Martial arts sport h/week	n=92 0.27 (1.02)	n=46 0.20 (0.98)	-0.08 (-0.41-0.24) $p = 0.614$
Martial arts sport METS	n=92 246 (930)	n=46 208.4 (1031)	-46.22 (-372-279) $p = 0.942$
Swimming h/week	n=92 0.33 (0.65)	n=46 0.23 (0.59)	-0.06 (-0.25-0.13) $p = 0.538$
Swimming METS	n=92 151.5 (300.4)	n=46 106.8 (280.8)	-34.24 (-126-57) $p = 0.460$
Football h/week	n=91 0.46 (1.08)	n=46 0.20 (0.54)	-0.25 (-0.53-0.02) $p = 0.073$
Football METS	n=91 261.3 (636.9)	n=46 117.3 (328.7)	-150.59 (-315-14) $p = 0.073$
Jogging h/week	n=92 1.77 (2.00)	n=46 1.29 (2.43)	-0.33 (1.20-0.53) p=0.448
Jogging METS	n=92 977 (1161)	n=46 703 (1280)	-255.11 (-730-220) $p = 0.290$
Cycling h/week	n=92 2.36 (3.10)	n=46 1.10 (1.75)	-1.51 (-2.39--0.62) $p = 0.001$
Cycling METS	n=92 1514 (1967)	n=46 713 (1139)	-987.76 (-1552--424) $p = 0.001$
Vigorous METS/week	n=90 3953 (2688)	n=46 2212 (2293)	-1791.86 (-2650--934) $p = 0.000$

Table III. Spiroergometry: description and estimated group differences (linear regression adjusted for age).

Spiroergometry values	FF	SC	SC vs. FF, CI difference CI *p*-value
	number, mean, (SD)		
HR_{max}	n=97 175.0 (14.4)	n=46 167.7 (17.5)	-3.29 (-8.57-1.98) $p = 0.219$
HR_{RCPr}	n=97 130.7 (20.6)	n=46 129.4 (22.0)	0.10 (-7.65-7.45) $p = 0.979$
VO_{2max}	n=97 3.17 (0.44)	n=46 2.85 (0.52)	-0.24 (-0.42--0.07) $p = 0.007$
Absolute VO_{2AT}	n=97 1.56 (0.53)	n=46 1.47 (0.47)	-0.08 (-0.26-0.10) $p = 0.375$
Absolute VO_{2RCP}	n=97 2.14 (0.60)	n=46 2.04 (0.65)	-0.11 (-0.34-0.11) $p = 0.329$
Relative VO_{2max}	n=97 37.3 (6.3)	n=46 34.1 (8.1)	-1.88 (-4.47-0.70) $p = 0.152$
Relative VO_{2AT}	n=97 18.7 (6.3)	n=46 18.3 (9.4)	0.01 (-3.08-3.05) $p = 0.993$
Relative VO_{2RCP}	n=97 25.4 (7.3)	n=46 24.0 (8.2)	-1.17 (-3.93-1.60) $p = 0.406$
W_{max}	n=97 299.1 (43.3)	n=46 257.7 (46.9)	-34.02 (-49.95--18.08) $p = 0.000$
Wmax/kg	n=97 3.53 (0.64)	n=46 3.03 (0.74)	-0.38 (-0.62--0.14) $p = 0.002$
METS, absolute	n=97 10.7 (1.8)	n=46 9.6 (2.3)	-0.66 (-1.40-0.08) $p = 0.078$

HR_{max} = maximum heart rate; HR_{RCP} = heart rate at respiratory compensation point; METS = metabolic equivalents; n = number of participants; RCP = respiratory compensation point; Relative = absolute value in ml/kg^{-1} · min^{-1}; VO_{2max} = maximum oxygen uptake; VO_{2AT} = oxygen uptake at aerobic threshold ;VO_{2RCP} = oxygen uptake at respiratory compensation point; W_{max} = maximum watt.

ments showed a tendency to higher values in SCs but without significance.

Metabolic Parameters and Metabolic Syndrome and Framingham Score

Metabolic parameters and Framingham score are visible in Table V. All metabolic parameters showed no significant differences. Metabolic syndrome[28], a composite of three minimum factors from all the factors involved (waist difference ≥ 94, systolic blood pressure ≥ 130 mmHg, fasting glucose ≥ 100 mg/dl, triglycerides ≥ 150 mg/dl, HDL-cholesterol ≤ 40 mg/dl,) was found in 12 subjects out of the 97 FFs (12.4%) and in

Table IV. Carotid intima thickness measurements.

Values of IMT measurements	FF			SC			CI, difference CI *p*-value
	n	mean	SD	n	mean	SD	
Left auto IMT Post AVG (mm)	96	0.69	0.19	45	0.81	0.20	0.07 (0.01-0.14) $p = 0.030$
Left auto IMT Post MAX (mm)	96	1.02	0.27	45	1.14	0.29	0.06 (-0.04-0.15) $p = 0.255$
Left auto IMT Post MIN	96	0.35	0.16	45	0.48	0.20	0.09 (0.02-0.15) $p = 0.010$
Right auto IMT Post AVG (mm)	96	0.71	0.19	45	0.79	0.20	0.03 (-0.04-0.10) $p = 0.400$
Right auto IMT Post MAX (mm)	96	1.04	0.30	45	1.12	0.31	0.01 (-0.10-0.11) $p = 0.901$

auto = automatic border detection; IMT = intima thickness; post = posterior wall of the carotid artery; AVG: average value; MAX = maximal value measured automatically or manually, MIN = minimal value measured automatically or manually.

14 subjects out of the 46 SCs (30.4%). Logistic regression analysis, age-adjusted showed a double higher feasibility of metabolic syndrome in SCs, but without significance [Odds Ratio 2.1 (0.8-5.4), p=0.141].

Smoking behavior was group independent without significant differences between the groups (FFs 17.5%, SCs 10.9%). Logistic regression analysis[29] showed odds ratio 0.6 (0.2-1.7), p=0.309.

Lipoprotein(a) > 30 mg/dl was found in 36 FFs (37.1%) FFs and in 17 SCs (37.0%).

Homocysteine > 15 mg/dl was shown in 28 (28.9%) FFs and in 21 (45.7%) SCs. Cardiovascular Framingham 10 years risk score[30] was similar in both groups (Table V).

Discussion

General Discussion

This study shows that sedentary occupations (SCs) is associated with higher prevalence of metabolic syndrome, higher waist circumference values and increased intima thickness among men. Occupation involving more physical activity (FFs) demonstrated higher physical strength and better values for VO_{2max} and power (W/kg).

All examined German FFs were career firefighters under continuous supervising for health and fitness. In the USA, 72% of FFs are volunteers and only 28% career FFs[31]. In the current study we have examined two occupations of German civil servants who have significantly different levels of occupational physical activity. A comparison of this study's results with the current literature for the general population can be interesting. Jackson et al[32] described in men (aged 48±10.3 years) a BMI of 25.9±3.3 and 11.7% current smokers. Using a treadmill test and average METS (absolute METS in our study) of 12.3±2.3 were reached. In a gender mixed cohort of 20,329 Caucasians, Lakoski et al[33] reported a mean cardiorespiratory level of 40-49 years aged men of 10.7±1.9 METS. BMI in this group (28.1 ±3.2) was comparable with results of our study. Systolic blood pressure in mixed genders was 120.2 (±14.0) and diastolic blood pressure 81.6 (±9.7) and 13.7% were current smokers.

Cardiorespiratory Fitness in Observed Occupations

Physical activity is worldwide recognized as one of the most important protector of cardiovascular diseases and cancer[34-37]. Cardiorespiratory fitness protects against obesity and diabetes

Table V. Metabolic blood parameters and Framingham values.

Metabolic blood parameters/Framingham values	FF			SC			CI difference CI *p*-value
	n	mean	SD	n	mean	SD	
HbA1c (%)	97	5.4	0.3	46	5.4	0.6	-0.09 (-0.25-0.07) $p = 0.255$
Glucose (mg/dl)	97	65.5	17.6	46	64.3	22.1	-3.07 (-10.18-4.04) $p = 0.394$
Cholesterol (mg/dl)	97	199.1	34.2	46	206.6	29.9	-0.88 (-10.87-9.11) $p = 0.862$
Triglycerides (mg/dl)	97	142.2	75.1	46	162.1	91.4	9.55 (-19.37-38.47) $p = 0.515$
HDL cholesterol (mg/dl)	97	55.5	12.7	46	55.8	14.8	0.61 (-4.18-5.40) $p = 0.802$
LDL cholesterol (mg/dl)	96	115.6	31.6	46	118.6	23.6	-3.40 (-12.71-5.92) p = 0.472
Uric acid (mg/dl)	97	5.6	1.1	46	5.7	0.9	0.09 (-0.28-0.46) $p = 0.631$
Creatinine (mg/dl)	97	0.94	0.16	46	0.89	0.13	-0.05 (-0.10--0.00) $p = 0.041$
C-reactive protein (mg/dl)	97	0.24	0.86	46	0.27	0.63	0.03 (-0.25-0.30) $p = 0.855$
Homocysteine (mmol/l)	97	14.1	3.1	46	15.8	4.1	1.20 (-0.04-2.44) $p = 0.057$
10 years risk Framingham (%)	97	6.1	5.4	46	9.7	9.2	1.07 (-0.98-3.12) $p = 0.303$
Heart/Vascular Age (Framingham)	97	42.9	12.7	46	49.6	15.5	0.27 (-2.53-3.06) $p = 0.851$

mellitus[38-40]. An epidemiological environmental study from the fifties demonstrated an association between coronary artery disease to physical activity in lower socio-economical group[14]. Low socioeconomic status is more linked to lower physical activity[41], lower physical performance in the elderly[40] and also increase in adverse prognosis[5,41].

Firefighters[42] need a maximal high cardiorespiratory fitness to act in difficult circumstances and with full heavy weight emergency equipment. The estimated[42] relVO_{2max} (VO_{2max} ml/kg^{-1} · min^{-1}) proposed for firefighting ranges from 33.6 ml/kg^{-1} · min^{-1} to 46 ml/kg^{-1} · min^{-1}. The physiological demands[43] for the firefighter candidate are in average 38 ml/kg^{-1} · min^{-1}. The problem of relVO_{2max} ranges is the use of different equipment for VO_{2max} measurements[42]. German firefighters showed an acceptable average value of VO_{2max}, but it is lower than in recreational triathletes for example[44]. An emergency situation and full emergency equipment cause a need for higher VO_{2max}, in some well-trained firefighters of our study we reached a maximal value of 54 ml/kg^{-1} · min^{-1}. The lowest was 26 ml/kg^{-1} · min^{-1}. VO_{2max} as an absolute value was significantly higher in FFs (3.17±0.44 L/min) when compared to SCs 2.85±0.52 L/min (-0.21 CI -0.39-0.04, p=0.018). Surprisingly, relative VO_{2max} (in ml/kg^{-1} ·min$^{-1)}$ and aerobic capacity (VO_{2AT}) was not different in both groups. Maximal power (W_{max}) was significant higher in FFs than in SCs (-32.07 CI -47.9-16.2, p=0.004). After weight adjustment (W_{max}/kg) FFs were stronger than SCs 3.03±0.74 W/kg (-0.36 CI 0.60-0.12, p=0.004).

Office workers from Malaysia[45] showed a relVO_{2max} of 24±3.8 ml/kg^{-1} · min^{-1}. Korean office workers demonstrated a relVO_{2max} of 32.4±5.4 ml/kg^{-1} min^{-1}[46]. Duque et al[47] described in healthy men (aged 39.3±7.8) a VO_{2max} of 2.82±0.4 l/min and relVO_{2max} of 40.5±5.5 ml/kg^{-1} min^{-1}.

Krausharr et al[48] examined 83 obese employers of a German electronics manufacturer. These participants showed body weight up to 92.6 ± 13.1 and a VO_{2max} of 32.2 ± 8.01 ml/kg^{-1} · min^{-1}. Spiroergometry was performed with similar equipment as in our study.

Maximal aerobic power of 2.82 l in healthy controls was reported from Duque et al[47], this is equivalent to the determined VO_{2max} of SCs in our study. It can be assumed, that the VO_{2max} and $relVO_{2max}$ values estimated in SCs are similar to the healthy volunteers of a "normal" population. It can be expected that this high socioeconomic status leads to better health conditions and better physical activity in leisure-time[49-51].

Carotid Atherosclerosis

Lynch et al[52] described a strong correlation between socioeconomic status and atherosclerosis in unselected population. White-collar workers showed significant lower IMT in comparison to blue-collar workers (0.78 mm *vs.* 0.84 mm)[52]. Krause at al[23] demonstrated that high expenditures at work are associated with an accelerated progression of atherosclerosis even after control for virtually all known cardiovascular risk factors. They suggested the hemodynamic theory of carotid atherosclerosis. In our study, the lower physical activity of SCs was linked with a small but significant increase of carotid intima thickness. Hartley et al[53] described a high and positive association of intima thickness with metabolic syndrome in female urban police officers. Nine published prospective studies, that included at least 1000 asymptomatic participants have examined carotid intima thickness and risk of cardiovascular disease[54]. Each study demonstrated that increased carotid intima thickness was significantly associated with risk for myocardial infarction, stroke, death from coronary heart disease, or a combination of these events[54]. Low physical activity was identified as one of risk factors for increased carotid intima thickness[3]. Findings of our study support the suggestion that sedentary occupation is more associated with higher risk of arteriosclerotic disease than an occupation with a higher physical activity.

Metabolic Risks, and Obesity

Firefighting is widely regarded as a hazardous occupation. Soteriades et al[55] reported that firefighters with on-duty fatalities had a twofold higher relative risk for tobacco abuse, threefold higher risk for obesity and similarly twofold higher risk for elevated cholesterol. Metabolic syndrome is inversely related to cardiorespiratory fitness in the career FFs[56]. In this cited study with 957 firefighters triglycerides were elevated in 28.5%, HDL lowered in 40.8%, and blood glucose was > 100 mg/dl in 26.1% participants. In our study of German firefighters the situation was better, no metabolic risk was found, only in 37% Lp(a) was > 30/mg/dL. Lp(a) is genetically determined and a known risk factor for coronary disease[29] and thromboembolic events[29,57]. So far, this factor has never been determined in FFs or SCs than in our study.

Obesity seems to be common in US firefighters and gets worse during follow up to an average of an BMI of 30[55]. Wilkinson et al[58] reported that 82.5% of firefighters are overweight (BMI 25.0-29.9 kg/m^2) or obese (BMI > 30.0 kg/m^2).

In our study we found significant difference in the prevalence of metabolic syndrome within the two groups studied. Metabolic syndrome[28] defined as a minimum 3 of all contributing factors (waist difference ≥ 94, systolic blood pressure ≥ 130 mmHg, fasting glucose ≥ 100 mg/dl, triglycerides ≥ 150 mg/dl, HDL-cholesterol ≤ 40 mg/dl,) was found in 13.4% of FFs and in 30.43% of SCs.

Clear data about sedentary civil servants that can be compared to the sedentary clerks of our study are difficult to find and can only be indirectly achieved from studies in Britain[59] and the Netherlands[60,61]. It can be suggested that the current BMI value (2014) has the tendency to be higher in German civil servants (26.4 ± 4.1) compared to British civil servants (BS) 1974 (24.5 ± 0.09)[59]. 43.5% of German sedentary clerks were overweight but only 13% were obese. It seems that smoking behavior has changed (current smokers 28.8% in British servants, but only 20% currently in German sedentary clerks).

Cholesterol levels seem to be not clinically different: British civil servants 201 mg/dl ± 1.72 and German sedentary clerks 206.6 ± 29.9. The values were lower in our study compared to civil servants in the Netherlands (1953-1954)[60]. Civil servants in the cited study showed high cholesterol levels (266 ± 50 mg/dl) but a similar BMI as British servants (24.5 ± 3.5).

Limitations of the Study

Results of self-reported activity in our study may be affected by self-image of the occupational group. A lot of studies have focused on self-reported physical activity measures which are affected by recall bias[62]. A voluntary character of participation should be reconsidered; this voluntary character of the participation might influence the absolute values/results, but not the differences between the groups. A main focus in this study was to examine the group differences and not to measure the absolute values in an occupational group. In a democratic country there are no other ethical alternatives for a similar study.

Conclusions

This study concludes that waist circumference in the FFs was smaller than in the SCs and metabolic syndrome had lower prevalence in the FFs, both of which are independent predictors of cardiovascular risk. Intima thickness was significantly increased in the SCs, as sign for an early arteriosclerosis. All these findings suggest that general risk of arteriosclerosis is more linked to sedentary occupation. Moreover, the FF group of this study seem to be less frequently obese (10.3%) as US colleagues (up to 40%)[55].

We suggest a potential role of proactive diet and physical training programs for sedentary clerks to reduce the burden of cardiovascular diseases. This strategy may be considered both by the governmental and corporate organizations for sedentary occupational employees. Also, community interventions on health and well-being need clearer strategies so that they are suited to improve prognosis and public health[63]. Unfortunately, the complexity of the obesity phenomenon seems to be hampering all efforts[64,65].

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Conflict of Interest

The Authors declare that they have no conflict of interests.

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