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THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY LEVEL AND SELECTED CARDIOVASCULAR RISK FACTORS AND MORTALITY OF MALES ≥ 50 YEARS IN POLAND – THE RESULTS OF FOLLOW-UP OF PARTICIPANTS OF NATIONAL MULTICENTRE HEALTH SURVEY WOBASZ

JANUSZ ŚMIGIELSKI[1], JOANNA RUSZKOWSKA[2], WALERIAN PIOTROWSKI[3], MARIA POLAKOWSKA[3], WOJCIECH BIELECKI[4], WOJCIECH HANKE[5], and WOJCIECH DRYGAS[2,3]

[1] Medical University of Lodz, Łódź, Poland
Department of Geriatrics, Healthy Ageing Research Centre (HARC)
[2] Medical University of Lodz, Łódź, Poland
Department of Preventive Medicine
[3] Institute of Cardiology, Warszawa, Poland
Department of Epidemiology, Cardiovascular Disease Prevention and Health Promotion
[4] Medical University of Lodz, Łódź, Poland
Department of Social Pathology
[5] Medical University of Lodz, Łódź, Poland
Department of Computer Science and Medical Statistics

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Corresponding author: W. Hanke, Medical University of Lodz, Department of Computer Science and Medical Statistics, Hallera 1, 90-647 Łódź, Poland (e-mail: wojciech.hanke@umed.lodz.pl).

Abstract
Objectives: The role of leisure-time physical activity in reducing all-cause and cardiovascular mortality is well explored. The knowledge on occupational and commuting physical activity continues to be ambiguous and misleading. The aim of the study is to assess the influence of different kinds of physical activity on cardiovascular mortality risk in men. **Material and Methods:** Data analysis on physical activity level and other selected cardiovascular risk factors acquired from 3577 men in the age between 50–80 years who participated in the National Multicenter Health Survey WOBASZ (Wieloośrodkowe Ogólnopolskie Badanie Stanu Zdrowia), Poland (2003–2005) was linked with male mortality in 2004–2009. Data about causes of deaths were obtained from the Central Statistical Office and the Population Electronic Register. **Results:** Among males aged 50–59 years, the strongest risk factor was living in large settlements and provincial capitals as a place of residence and the most protective factor was occupational physical activity. In the age group 60–69 years and 70–80 years, the strongest protective effect was observed for leisure-time physical activity. In men aged between 70–80 years (unlike in the 50–59 years age group), the protective effect of large settlements and provincial capitals as a place of residence was noted. **Conclusions:** Occupational physical activity significantly reduced cardiovascular mortality in men aged 50–69 years, while for leisure-time activity the positive effect was observed in age group 60–69 years and 70–80 years. On the other hand, for the inhabitants of large settlements and provincial capitals, significantly higher risk of cardiovascular mortality in the age group 50–69 years and lower risk in the age group ≥ 70 years was noted, both in comparison with smaller places of residence.

Key words:
Health, Physical activity, Workers, Mortality, Cardiovascular disease, Place of living

INTRODUCTION

Cardiovascular diseases (CVD), although permanently decreasing, still result in almost 50% of all NCD (noncommunicable disease) deaths across Europe. In Poland, 48% of all NCD deaths are attributed to CVD [1,2]. According to the World Health Organization (WHO) report entitled "Global health risks: Mortality and burden of disease attributable to selected major risks," physical inactivity occupies 4th place on the list of the leading risk factors responsible for global deaths [3].

World Health Organization experts emphasize that participation in 150 min of moderate physical activity each week is estimated to reduce the risk of ischemic heart disease by approximately 30%, as well as to significantly reduce the risk of stroke and hypertension [4].

The results of two-decade studies suggest that regular leisure-time physical activity influences both all-cause and cardiovascular disease mortality [5]. Furthermore, the latest publications report a protective effect of physical activity regardless of the presence of metabolic risk factors [6,7]. Importantly, men seem to benefit more than women [8,9]. Overall evidence indicates that a broad spectrum of health benefits resulting from an active lifestyle can be achieved even in the later years of life.

In general, beneficial influence of leisure-time physical activity has been very well documented [8,10,11].

The scope of our knowledge in the field of occupational physical activity is much more complicated. Some studies have revealed that a reduced risk of all-cause and CVD mortality was observed for moderate or high levels of occupational physical activity [12,13]. On the contrary, the results presented in publications of Johansson et al. [14] and Hu et al. [15] suggest that a higher occupational activity is associated with a higher level of all-cause mortality.

As regards the role of commuting physical activity as a cardiovascular protective factor, some authors have indicated that it is significantly associated with a reduced 10-year risk of coronary heart disease (CHD) incidence and cardiovascular mortality, but only among women [16]. In the case of men, an increased commuting activity was linked to the lower risks of abdominal obesity, increased high-density cholesterol and decreased triglyceride levels [17].

Objectives

Overall, the lack of consensus on the role of particular domains of total physical activity on cardiovascular risk has encouraged the authors to address this issue.

The aim of the presented study is to assess the influence of different kinds of physical activity (leisure-time, commuting and occupational) as well as other selected risk factors in men aged 50–80 years on the risk of cardiovascular mortality.

MATERIAL AND METHODS

The analysis linked data on a physical activity level and other selected cardiovascular risk factors in 3577 men aged ≥ 50 years, who participated in the National Multicentre Health Survey WOBASZ (Wieloośrodkowe Ogólnopolskie Badanie Stanu Zdrowia), Poland (2003–2005) with male mortality in 2004–2009 – the data obtained from the Central Statistical Office (Główny Urząd Statystyczny – GUS) and from Population Electronic Register (Powszechny Elektroniczny System Ewidencji Ludności – PESEL). The average follow-up period for the deceased persons was 39.37 months with minimum of 2.86 months and maximum 69.16 months.

National Multicentre Health Survey WOBASZ was conducted by the Institute of Cardiology in cooperation with the Medical University of Gdańsk, Medical University of Lodz, Poznan University of Medical Sciences, Medical University of Silesia in Katowice and Jagiellonian University Medical College in Kraków. The study group was created in a two-step random selection process stratified for province and the settlement size. In each of 16 provinces of Poland, a set of 2 small settlements (< 8000 of residents), 2 medium size settlements (8000–40 000 of residents) and 2 large settlements (> 40 000 of residents). In each settlement, a group of 100 men and 100 women aged 20–74 years was randomly selected. The response rate, after exclusion of the individuals unavailable for examination (death, change of address), was 74% for men and 79% for women. All in all, 13 545 respondents reported for the study; a wide range of cardiovascular risk factors was evaluated on the basis of questionnaire data, laboratory and anthropometric tests. The group included 6731 men at the age of ≥ 50 years, which are a study sample for reported analysis.

In our study, the analysis of the influence on survival probability included the following variables:
- commuting physical activity (physical activity 1) – those who walk or cycle to/from work for at least 15 min a day were perceived as physically active,
- occupational physical activity (physical activity 2) – those who take intensive physical work at least during a half of their overall work time were regarded as physically active,
- leisure-time physical activity (physical activity 3) – those who undertook physical activity for 30 min daily or at least 4 times a week were considered physically active,
- lack of any of the above described types of physical activity (a sedentary lifestyle; physical activity 0),
- residence (size of settlement),
- age,
- smoking status (a current smoker, an ex-smoker, a lifetime non-smoker),
- average systolic and diastolic blood pressure,
- Body Mass Index (BMI),
- high-density lipoprotein (HDL) level,
- plasma homocysteine (tHcy) level,
- diagnosis of type 2 diabetes mellitus.

The methods of physical activity analysis and description of physical activity of Polish population based on WOBASZ study have been published elsewhere [18].

The significance of the influence of the 3 types of physical activity was analysed in 3 age groups: 50–59 years, 60–69 years and ≥ 70 years of age. As the information concerning occupational and commuting activity was reported for activities which were true during the interview, these types of activity were not analysed in the oldest age group.

Statistical analysis

Mortality statistics (censored variables) does not allow an analysis of deaths by age based on the well-known parametric and non-parametric tests, therefore, in this article the Cox proportional hazard regression model was used [19]:

$$H(t, x_1, x_2, ..., x_n) = h_0(t)\ exp\ (\beta_1 \times x_1 + \beta_2 \times x_2 + \beta_n \times x_n) \quad (1)$$

where:
$H(t, x_1, x_2, ..., x_n)$ – the resultant hazard,
n – explanatory variables x_1, x_2, ..., x_n and the model parameters β_1, β_2, ..., β_n,
t – survival time.

The statistical analysis of survival time for men, depending on the physical activity factors, socio-medical characteristics and the risk factors of cardiovascular diseases was carried out on the basis of the National Multicentre Health Survey WOBASZ conducted over the years 2003–2005, and GUS data provided for the period 2004–2009. The level of statistical significance was set at $p < 0.05$. Time in the model was defined as time (in months) from the examination (2003–2005) till the end of 2009 or death, whichever came first.
For the purposes of this article, the statistical calculations were made using the Statistica 10.0 software.

RESULTS

Study group characteristic

The study group (3577 men aged ≥ 50 years) was chosen from among the 6731 male participants of the National Multicentre Health Survey WOBASZ conducted in Poland over the years 2003–2005. The average age was 61.95 years (standard deviation = 8.5 years, median = 60 years).
As regards settlement size distribution of the participants, it was almost even, i.e., 1167 men (32.63%) came from small settlements (≤ 8000 inhabitants), 1130 (31.59%) from medium-size settlements (8001–40 000 inhabitants) and 1280 (35.78%) from large settlements and provincial capitals (> 40 000 inhabitants).
Vast majority of the males were married (87.23%). Almost 2/3 had elementary education (65.65%), less than every fourth participant had college education (24.87%), and every tenth had a university education (9.48%).
The majority of the men at the time of the initial study (51.84%) had retired or had received pension, yet about 30% were still full-time employed (29.09%) (Table 1).
Among the study participants, 37% were life-long non-smokers, 38% were ex-smokers, and 25% were current smokers. The percentage of life-long non-smokers was decreasing with age and, simultaneously, the number of ex-smokers was rising.
Body Mass Index > 30 kg/m^2, indicating obesity was noted in almost 27% of the respondents, whereas diabetes was recorded in 413 cases (11.95%). The percentage of the individuals with those risk factors increased proportionally to age (Table 2).

Table 1. Socio-demographic characteristics by age of examined men

Variable	Respondents [n (%)]			
	50–59 years old (N = 1 690)	60–69 years old (N = 1 055)	70–80 years old (N = 832)	total (N = 3 577)
Size of settlement [n of residents]				
small (< 8 000)	570 (33.73)	341 (32.32)	256 (30.77)	1 167 (32.63)
medium (8 000–40 000)	512 (30.30)	346 (32.80)	272 (32.69)	1 130 (31.59)
large (> 40 000)	608 (35.97)	368 (34.88)	304 (36.54)	1 280 (35.78)
total	1 690 (100.00)	1 055 (100.00)	832 (100.00)	3 577 (100.00)

Table 1. Socio-demographic characteristics by age of examined men – cont.

Variable	Respondents [n (%)]			
	50–59 years old (N = 1 690)	60–69 years old (N = 1 055)	70–80 years old (N = 832)	total (N = 3 577)
Marital status				
married	1 461 (86.55)	923 (87.74)	732 (88.09)	3 116 (87.26)
widowed	19 (1.13)	39 (3.71)	69 (8.30)	127 (3.56)
single	134 (7.94)	46 (4.37)	13 (1.56)	193 (5.40)
divorced or in separation	74 (4.38)	44 (4.18)	17 (2.05)	135 (3.78)
total	1 688 (100.00)	1 052 (100.00)	831 (100.00)	3 571 (100.00)
Education				
primary	1 083 (64.12)	682 (64.71)	582 (69.95)	2 347 (65.65)
college	436 (25.81)	270 (25.62)	183 (22.00)	889 (24.87)
university	170 (10.07)	102 (9.68)	67 (8.05)	339 (9.48)
total	1 689 (100.00)	1 054 (100.00)	832 (100.00)	3 575 (100.00)
Employment				
fulltime	838 (49.97)	191 (18.14)	7 (0.84)	1 036 (29.09)
part-time	41 (2.44)	24 (2.28)	8 (0.96)	73 (2.05)
farmers	154 (9.18)	43 (4.08)	2 (0.24)	199 (5.59)
retired or disabled	363 (21.65)	672 (63.82)	811 (97.60)	1 846 (51.84)
unemployed with compensation	92 (5.49)	74 (7.03)	2 (0.24)	168 (4.72)
unemployed without compensation	189 (11.27)	49 (4.65)	1 (0.12)	239 (6.71)
total	1 677 (100.00)	1 053 (100.00)	831 (100.00)	3 561 (100.00)

Table 2. Selected cardiovascular risk factors by age of examined men

Cardiovascular risk factor	Respondents [n (%)]			
	50–59 years old (N = 1 690)	60–69 years old (N = 1 055)	70–80 years old (N = 832)	total (N = 3 577)
Smoking				
never smoker	747 (44.92)	370 (35.58)	174 (21.19)	1 291 (36.63)
ex-smoker	517 (31.09)	398 (38.27)	427 (52.01)	1 342 (38.08)
current smoker	399 (23.99)	272 (26.15)	220 (26.80)	891 (25.28)
total	1 663 (100.00)	1 040 (100.00)	821 (100.00)	3 524 (100.00)
Body mass index (BMI)				
< 30	1 251 (74.69)	742 (71.21)	601 (72.67)	2 594 (73.19)
≥ 30	424 (25.31)	300 (28.79)	226 (27.33)	950 (26.81)
total	1 675 (100.00)	1 042 (100.00)	827 (100.00)	3 544 (100.00)

Table 2. Selected cardiovascular risk factors by age of examined men – cont.

Cardiovascular risk factor	Respondents [n (%)] 50–59 years old (N = 1 690)	60–69 years old (N = 1 055)	70–80 years old (N = 832)	total (N = 3 577)
Diabetes				
yes	144 (8.77)	140 (13.82)	129 (16.08)	413 (11.95)
no	1 498 (91.23)	873 (86.18)	673 (83.92)	3 044 (88.05)
total	1 642 (100.00)	1 013 (100.00)	802 (100.00)	3 457 (100.00)

Commuting physical activity (physical activity 1) was reported by 6.8% of the 50–59 age group, 3.03% of 60–69 age group and 0.25% of the oldest group (Table 3). Occupational physical activity (physical activity 2) mostly applied to males aged 50–59 years (over 29%) and 60–69 years (10.43%). Leisure-time physical activity tended to be undertaken by almost 48% of the research participants and the percentage of those individuals increased along with age from over 37% in the youngest to over 44% in the oldest age group. The group of 48% subjects practised none of the above mentioned physical activities (coded as physical activity 0). The prevalence of such status was elevating along with age, from 43% in the youngest group to above 55% in the oldest one (Table 3).

Mean HDL level was 1.36±0.42 mmol/l, homocysteine level 11.61±5.23 μmol/l, the mean systolic and diastolic blood pressure values were 142.94±20.63 mm Hg and 86.93±11.93 mm Hg, respectively (Table 2 and 4).
Both homocysteine and systolic blood pressure values increased with age, contrary to the HDL level (Table 4).

Cardiovascular mortality analysis
Over the years 2004–2009, 150 deaths were reported in the examined population. The males died most frequently from ischemic heart disease (41.33% total deaths), cerebrovascular diseases (14.67%), artery and capillary diseases (14%), and other heart illnesses, i.e., nonrheumatic mitral valve dysfunction, cardiac arrest, heart failure,

Table 3. Physical activity by age of examined men

Physical activity	Respondents 50–59 years old (N = 1 690)		60–69 years old (N = 1 055)		70–80 years old (N = 832)		total (N = 3 577)	
	n	rate[a]	n	rate[a]	n	rate[a]	n	rate[a]
1	115	6.80	32	3.03	2	0.24	149	4.17
2	492	29.11	110	10.43	6	0.72	608	17.00
3	628	37.16	451	42.57	367	44.11	1 446	40.42
0	727	43.02	527	49.95	461	55.41	1 715	47.95

1 – commuting physical activity (those who walk or cycle to/from work for at least 15 min a day were perceived as physically active); 2 – occupational physical activity (those who take intensive physical work at least half of overall work time were regarded as physically active); 3 – leisure-time physical activity (those who undertake physical activity daily for at least 30 min, 4 times a week were considered physically active); 0 – lack of any of the above described types of physical activity (a sedentary lifestyle).
[a] Per 100 respondents.

Table 4. Cardiovascular risk factors by age of examined men

Variable	Respondents [M±SD (Me)]			
	50–59 years old (N = 1 690)	60–69 years old (N = 1 055)	70–80 years old (N = 832)	total (N = 3 577)
HDL [mmol/l]	1.38±0.46 (1.29)	1.36±0.40 (1.29)	1.33±0.37 (1.27)	1.36±0.42 (1.29)
Homocysteine [μmol/l]	10.96±4.93 (9.93)	11.98±6.27 (10.70)	12.50±3.99 (11.70)	11.61±5.23 (10.60)
Blood pressure [mm Hg]				
SBP	139.03±18.76 (136.00)	145.37±21.13 (139.50)	147.82±22.07 (144.00)	142.94±20.63 (138.50)
DBP	86.94±11.82 (85.50)	87.89±12.06 (86.50)	85.71±11.89 (85.00)	86.93±11.93 (85.50)

HDL – high density lipoprotein; SBP – systolic blood pressure; DBP – diastolic blood pressure.
M – mean; SD – standard deviation; Me – median.

unspecific heart disease and complications of heart diseases (15.33% in total).

For each cause of death that has been mentioned above, an increase in mortality alongside with age was observed. The largest relative increase was noted for cerebrovascular diseases; from 0.06/1000 in the youngest to 1.32/1000 in the oldest age group (Table 5).

The statistical analysis showed significant influence of each kind of physical activity (physical activity 1, 2, 3 and 0) on cardiovascular mortality.

The men with physical activity 1 and 2 were characterized by the lowest mortality rates (0.67% and 0.66%, respectively). A higher rate was found in the case of the men with physical activity 3 (3.11%), and the highest for those with physical activity 0 (5.95%) (Table 6). A parallel analysis in the particular age groups showed a strong beneficial effect of physical activity 3 on mortality rates. The males who were practicing this kind of physical activity had lower death rates (1.59%, 3.33%, 5.45%, respectively, in the subsequent age groups) in comparison to the sedentary lifestyle participants (3.16%, 7.02% and 9.11%, respectively).

Univariate and multivariate analysis

In the univariate analysis in the youngest male age group, statistical significance ($p < 0.05$) was found in the case of the following risk factors: lack of physical activity 0 (a sedentary lifestyle), and living in large settlements and/or in provincial capitals (> 40 000 inhabitants). A significant protective effect was observed for occupational physical activity. The risk increased significantly along with homocysteine level. On the contrary, a significant decrease of this risk was found to occur along with the growth of HDL level. There was no significant relationship between systolic and diastolic blood pressure, BMI, leisure-time physical activity, age and cardiovascular mortality risk (Table 7).

In the age group of 60–69 years, the univariate analysis revealed statistical significance ($p < 0.05$) of 2 risk factors: physical activity 0 (a sedentary lifestyle) and age. Leisure-time physical activity turned out to be an important protective factor. A significant risk increase was found to occur along with the rising homocysteine level. On the other hand, the influence of diabetes mellitus, level of systolic and diastolic blood pressure, HDL, or BMI on mortality risk was not found to be statistically significant. In this age group, smoking was found to have a protective effect (Table 7).

In the oldest age group (70–80 years), contrary to the 50–59 age group, the univariate analysis revealed a statistically significant increase of this risk in small settlement inhabitants (up to 8000 persons). Significant protective effect was found for leisure-time physical activity. A statistically

Table 5. Deaths of men due to cardiovascular diseases (ICD-10)

Disease unit (ICD-10 code)	Deceased respondents							
	50–59 years (N = 1 690)		60–69 years (N = 1 055)		70–80 years (N = 832)		total (N = 3 577)	
	n (%)	mortality rate per 100 respondents	n (%)	mortality rate per 100 respondents	n (%)	mortality rate per 100 respondents	n (%)	mortality rate per 100 respondents
Ischemic heart diseases (I20, I21, I24, I25)	16 (44.44)	0.95	23 (44.23)	2.18	23 (37.10)	2.76	62 (41.33)	1.73
Other forms of heart disease (I34, I42, I46, I50, I51)	7 (19.44)	0.41	5 (9.62)	0.47	11 (17.74)	1.32	23 (15.33)	0.64
Cerebrovascular diseases (I61, I62, I63, I64, I67, I69)	1 (2.78)	0.06	10 (19.23)	0.95	11 (17.74)	1.32	22 (14.67)	0.62
Diseases of arteries. arterioles and capillaries (I70, I71, I72, I74)	4 (11.11)	0.24	6 (11.54)	0.57	11 (17.74)	1.32	21 (14.00)	0.59
Ill-defined and unknown causes of mortality (R96, R98)	5 (13.89)	0.30	6 (11.54)	0.57	0 (0.00)	0.00	11 (7.33)	0.31
Hypertensive diseases (I10, I11, I13)	3 (8.33)	0.18	1 (1.92)	0.09	4 (6.45)	0.48	8 (5.33)	0.22
Pulmonary heart disease and diseases of pulmonary circulation (I26, I27)	0 (0.00)	0.00	1 (1.92)	0.09	1 (1.61)	0.12	2 (1.33)	0.06
Chronic rheumatic heart diseases (I08)	0 (0.00)	0.00	0 (0.00)	0.00	1 (1.61)	0.12	1 (0.67)	0.03
Total	36 (100.00)	2.13	52 (100.00)	4.93	62 (7.45)	100.00	150 (100.00)	4.19

ICD-10 – International Statistical Classification of Diseases and Related Health Problems 10th Revision.

Table 6. Physical activity and cardiovascular mortality of examined men

Physical activity	Respondents											
	50–59 years old (N = 1 690)			60–69 years old (N = 1 055)			70–80 years old (N = 832)			total (N = 3 577)		
	respondents [n]	deaths [n]	mortality rate per 100 respondents	respondents [n]	deaths [n]	mortality rate per 100 respondents	respondents [n]	deaths [n]	mortality rate per 100 respondents	respondents [n]	deaths [n]	mortality rate per 100 respondents
1	115	1	0.87	32	0	0.00	2	0	0.00	149	1	0.67
2	492	4	0.81	110	0	0.00	6	0	0.00	608	4	0.66
3	628	10	1.59	451	15	3.33	367	20	5.45	1 446	45	3.11
0	727	23	3.16	527	37	7.02	461	42	9.11	1 715	102	5.95

Abbreviations as in Table 3.

Table 7. Cardiovascular mortality in men aged 50–80 – the Cox proportional hazards regression univariate model

Explanatory variable	Dependent variable: observation time [months] – numerical characteristics of the model				
	β parameter estimates (value)	asymptotic standard error of parameters	HR	Wald statistics value	probability level of Wald statistics
Age group 50–59 years (N = 1 690)					
physical activity					
1 (yes vs. no)	–0.945	1.014	0.39	0.87	0.352
2 (yes vs. no)	–1.201	0.530	0.30	5.13	**0.024**
3 (yes vs. no)	–0.434	0.372	0.65	1.36	0.243
0 (vs. any physical activity)	0.863	0.347	2.37	6.18	**0.013**
place of living (large settlement vs. others)	0.520	0.216	1.68	5.79	**0.016**
age (continuous variable)	0.082	0.059	1.09	1.90	0.168
current smokers vs. never smokers and ex-smokers	–0.517	0.240	0.60	4.65	**0.031**
blood pressure (M)					
SBP	0.013	0.008	1.01	2.57	0.109
DBP	0.008	0.014	1.01	0.31	0.575
BMI (≥ 30 vs. < 30)	0.299	0.361	1.35	0.69	0.407
HDL (continuous variable)	–0.604	0.448	0.55	1.82	0.178
homocysteine (continuous variable)	0.050	0.024	1.05	4.20	**0.040**
diabetes (yes vs. no)	–0.768	0.448	0.46	2.94	0.086
Age group 60–69 years (N = 1 055)					
physical activity					
3 (yes vs. no)	–0.629	0.306	0.53	4.23	**0.040**
0 (vs. any physical activity)	0.930	0.306	2.54	9.24	**0.002**
place of living (large settlement vs. others)	–0.129	0.170	0.88	0.58	0.447
age (continuous variable)	0.186	0.048	1.20	15.03	**0.000**
current smokers vs. never smokers and ex-smokers	–0.075	0.180	0.93	0.17	0.677
blood pressure (M)					
SBP	0.007	0.006	1.01	1.18	0.277
DBP	–0.001	0.012	1.00	0.02	0.899
BMI (≥ 30 vs. < 30)	–0.064	0.313	0.94	0.04	0.837
HDL (continuous variable)	–0.160	0.369	0.85	0.19	0.665
homocysteine (continuous variable)	0.053	0.011	1.05	22.17	**0.000**
diabetes (yes vs. no)	–0.576	0.341	0.56	2.85	**0.092**

Table 7. Cardiovascular mortality in men aged 50–80 – the Cox proportional hazards regression univariate model – cont.

Explanatory variable	Dependent variable: observation time [months] – numerical characteristics of the model				
	β parameter estimates (value)	asymptotic standard error of parameters	HR	Wald statistics value	probability level of Wald statistics
Age group 70–80 years (N = 832)					
physical activity 3 (yes vs. no)	–0.538	0.272	0.58	3.92	**0.048**
place of living (large settlement vs. others)	–0.322	0.157	0.72	4.20	**0.040**
age (continuous variable)	–0.064	0.043	0.94	2.19	0.139
current smokers vs. never smokers and ex-smokers	–0.224	0.185	0.80	1.46	0.227
blood pressure (M)					
SBP	–0.010	0.006	0.99	2.71	0.100
DBP	–0.020	0.011	0.98	3.15	0.076
BMI (≥ 30 vs. < 30)	–0.060	0.289	0.94	0.04	0.834
HDL (continuous variable)	–0.018	0.350	0.98	0.00	0.960
homocysteine (continuous variable)	0.074	0.034	1.08	4.74	**0.029**
diabetes (yes vs. no)	–0.068	0.345	0.93	0.04	0.844

HR – hazard ratio. Other abbreviations as in Table 2 and 4.
Bolded values mean $p < 0.05$.

significant mortality risk increase was observed alongside the rise in homocysteine level. No influence of smoking habit, systolic and diastolic blood pressure, HDL level, BMI and diabetes incidence on mortality risk was observed (Table 7).

The multivariate analysis results concerning the age group 50–59 years, in general, confirm the univariate analysis data. The highest risk was connected with large settlements and provincial capitals as a place of residence – it increased the mortality risk by over 60% compared to the males living in small settlements (hazard ratio (HR) = 1.65).

The strongest protective factors was presence of occupational physical activity (on the borderline of statistical significance). A statistically significant increase of mortality risk was found when the level of systolic blood pressure and tHcy were both taken into account. The influence of HDL, leisure-time physical activity, diastolic blood pressure, BMI and diabetes on cardiovascular mortality risk was not confirmed (Table 8).

In the multivariate analysis of the age group 60–69 years, age (HR = 1.315) and homocysteine level (HR = 1.09) were found to be significant cardiovascular mortality risk factors. The strongest protective effect was observed for leisure-time physical activity (HR = 0.537). Cardiovascular mortality risk was almost 2-fold lower for the active persons in this age group compared to the not active ones.

The influence of place of living, diabetes, HDL level, BMI, systolic and diastolic blood pressure on cardiovascular mortality risk was not confirmed, whereas smoking proved to be protective (Table 8).

Table 8. Cardiovascular mortality in men aged 50–80 – the Cox proportional hazards multivariate regression model

Explanatory variables	Dependent variable: observation time [months] – numerical characteristics of the model				
	β parameter estimates (value)	asymptotic standard error of beta parameters	HR	Wald statistics value	probability level of the Wald statistics
Age group 50–59 years (N = 1 690)					
physical activity					
1 (yes vs. no)	–0.753	1.022	0.471	0.543	0.461
2 (yes vs. no)	–1.007	0.538	0.365	3.498	0.061
3 (yes vs. no)	–0.270	0.377	0.763	0.515	0.473
place of living (large settlement vs. others)	0.499	0.219	1.647	5.184	**0.023**
age (continuous variable)	0.044	0.061	1.045	0.539	0.463
current smokers vs. never smokers and ex-smokers	–0.538	0.248	0.584	4.682	**0.030**
blood pressure (M)					
SBP	0.030	0.015	1.030	4.005	**0.045**
DBP	–0.042	0.025	0.958	2.803	0.094
BMI (≥ 30 vs. < 30)	0.189	0.404	1.209	0.220	0.639
HDL (continuous variable)	–0.347	0.441	0.707	0.619	0.431
homocysteine (continuous variable)	0.057	0.026	1.059	4.780	**0.029**
diabetes (yes vs. no)	–0.753	1.022	0.471	0.543	0.461
evaluation of matching the model to empirical data	$Chi^2 = 29.76$, $p = 0.003$				
Age group 60–69 years (N =1 055)					
physical activity 3 (yes vs. no)	–0.622	0.313	0.537	3.936	**0.047**
place of living (large settlement vs. others)	–0.086	0.176	1.295	0.240	0.624
age (continuous variable)	0.175	0.049	1.315	12.56	**0.000**
current smokers vs. never smokers and ex-smokers	–0.086	0.184	1.315	0.219	0.640
blood pressure (M)					
SBP	0.019	0.010	1.040	3.220	0.073
DBP	–0.028	0.019	1.010	2.128	0.144
BMI (≥ 30 vs. < 30)	–0.213	0.338	1.569	0.395	0.529
HDL (continuous variable)	–0.311	0.401	1.608	0.600	0.439
homocysteine (continuous variable)	0.061	0.013	1.090	22.245	**0.000**
diabetes (yes vs. no)	–0.429	0.359	1.317	1.423	0.232
evaluation of matching the model to empirical data	$Chi^2 = 37.61$, $p = 0.000$				

Table 8. Cardiovascular mortality in men aged 50–80 – the Cox proportional hazards multivariate regression model – cont.

Explanatory variables	Dependent variable: observation time [months] – numerical characteristics of the model				
	β parameter estimates (value)	asymptotic standard error of beta parameters	HR	Wald statistics value	probability level of the Wald statistics
Age group 70–80 years (N = 832)			70–80		
physical activity 3 (yes vs. no)	–0.499	0.276	0.607	3.258	0.071
place of living (large settlement vs. others)	–0.301	0.156	0.740	3.710	**0.050**
age (continuous variable)	–0.062	0.043	0.940	2.052	0.152
current smokers vs. never smokers and ex-smokers	–0.152	0.187	0.859	0.659	0.830
blood pressure (M)					
SBP	–0.002	0.009	0.999	0.046	0.326
DBP	–0.017	0.018	0.983	0.964	0.830
BMI (≥ 30 vs. < 30)	–0.038	0.308	0.963	0.015	0.902
HDL (continuous variable)	–0.003	0.360	0.997	0.001	0.992
homocysteine (continuous variable)	0.062	0.033	1.063	3.614	**0.050**
diabetes (yes vs. no)	–0.143	0.361	0.866	0.158	0.691
evaluation of matching the model to empirical data			$Chi^2 = 17.9$, $p = 0.05$		

Abbreviations as in Table 2, 4, and 7.

After a multivariable adjustment, in the age group of 70–80 year-old respondents, a protective effect of large settlements and provincial capitals as a place of residence (HR = 0.74) as well as leisure-time physical activity (HR = 0.607) was found. A statistically significant mortality risk increase was observed in parallel with the growth of homocysteine level (HR = 1.09). No significant influence of the participants age, diabetes, smoking, HDL level, BMI, systolic or diastolic blood pressure on cardiovascular mortality risk was documented (Table 8).

DISCUSSION

The results of our study demonstrate that the protective effect of physical activity on cardiovascular mortality rate can be observed regardless of the physical activity type and individuals' age. The research confirmed a crucial effect of leisure-time physical activity on cardiovascular mortality, which has been previously revealed in many other publications [6,8,10,11]. Apart from this, however, we also observed a 2-fold lower death risk in the active subjects compared to the sedentary males. Moreover, in our study, a beneficial effect of occupational physical activity on cardiovascular mortality was observed in the men aged 50–69 years, but not in the oldest age group. The reason for such a phenomenon seems to be obvious: in Poland, 70 years of age and above men are not occupationally active.

In the case of the age group 50–59 years, a protective effect of small settlements was observed. This may be a result of some unmeasured indicators of healthy lifestyle in our study such as: lower job stress, fewer time-pressure activities and general pro-family orientation, which might be more prevalent in small settlements in comparison with larger places.

Interestingly, in the case of cardiovascular mortality, smoking was found to have a protective effect. In the 50–59 years age group, this finding is probably a result of reverse causality. Men at this age, who are in good health, continue to smoke as long as smoking does not adversely influence their health.

In the oldest age group (70–80 years), contrary to the age group 50–59 years, the univariate analysis revealed a statistically significant increase of this risk in small settlement inhabitants (up to 8000 persons). We are confident that conditions of Polish men's everyday life, that is: accessibility of general practitioner (GP), and especially of other medical specialists, are the main factors contributing to that phenomenon. In small settlements, we observe a lower (compared with the men being the inhabitants of a large settlement) income, a lower level of education and as a consequence – a lower level of health culture, which is generally evidenced by the behavioral risk factors (alcohol abuse, daily smoking and a poor diet) [20].

The association between occupational physical activity and the lower risk of CVD and mortality was also observed by other authors [12,15]. However, it has to be underlined that in the authors' opinion its protective role in premature cardiovascular mortality probably depends on the occupational activity characteristics, and on the level of individuals' leisure-time physical activity. In line with our statement, Petersen et al. have noticed that occupational lifting of heavy loads by men, particularly among those with low total occupational and leisure-time physical activity, increased the cardiovascular risk [21]. Although some publications have reported a protective effect of occupational activity on the myocardiac infarction risk [22,23], the latest publications of Holtermann et al. suggest that high occupational physical activity can even increase cardiovascular and all-cause mortality, in particular among men with low levels of leisure-time physical activity [24,25].

Our observations confirm the results of other studies indicating that lack of any kind of physical activity is one of the strongest factors influencing cardiovascular mortality risk in males [8,10]. Moreover, Wilmot et al. in their review of 18 studies have concluded that a sedentary lifestyle is associated with an increased risk of diabetes mellitus, cardiovascular disease and cardiovascular and all-cause mortality [26].

Our study has several strong advantages. The size of the examined groups allowed to identify the subgroups with different patterns of physical activity. At the same time our WOBASZ study is – to our knowledge – one of the few projects which, in addition to the evaluation of physical activity, also covered a large scope of cardiovascular risk factors. Undoubtedly, a unique strength of our study is the fact that no similar publications from the middle-income countries of Central and Eastern Europe are currently accessible.

Although several relationships between the type of physical activity and cardiovascular mortality were found, we have to admit that the statistical power of the study to identify the effect of the examined risk factors might not be optimal. Such a situation is an effect of a relatively short follow-up period (5 years). In the future, the authors are planning to continue to follow mortality in the WOBASZ study.

The second limitation is the lack of possibility of lifetime physical activity assessment. However, it may be expected that the men who reported physical activity at the time of the survey, had been performing similar activity in the past. Some misclassification of the physical activity status might have taken place in the case of the elderly men, who reported no leisure-time physical activity at the time of the examination, while in the past they could have been much more active.

Another limitation of the study is the limited information to control the confounding due to socio-economic status of the examined persons. Nevertheless, the main socio-economic risk factors, such as smoking, diabetes or blood pressure, as well as BMI and HDL were included in the statistical models.

Reverse causality may bias the relationship between occupational physical activity and cardiovascular mortality. There is some "healthy-worker effect" in the process of selection to work requiring lifting of heavy loads. In the case of leisure-time activity, such decisions are made in early adulthood and the activities are usually continued in the middle-age and in elderly life as long as health status allows. It is likely that, due to the fact that the interview identified only persons with leisure-time physical activity at the time of the examination, some persons who had been active in the past were not qualified as still active. In other words, the group of not physically active individuals might include some persons who were active in the past but not at the time of examination. Such a misclassification would lead to underestimation of the effect rather than to the production of a spurious association.

Despite the limitations, our observations indicate that reducing a sedentary lifestyle provides a protective effect even in the oldest population group. Moreover, the importance of physical activity in the process of cardiovascular mortality prevention, regardless of a patient's individual characteristics and metabolic risk factors seems to be still underestimated, especially among the oldest individuals.

CONCLUSIONS

Leisure-time physical activity (30 min at least 4 times a week) in older age groups (≥ 60 years old) is a significant factor reducing the risk of cardiovascular death.

Occupational physical activity is a statistically significant protector against male cardiovascular mortality in the 50–59 years of age group.

Men between 50–59 years old, inhabitants of large settlements and provincial capitals have a significantly higher risk of cardiovascular mortality as compared to the inhabitants of small communities. Yet, in the age group of 70–80 years old men, this factor has a significant protective effect.

An increased homocysteine level is a statistically significant risk factor of cardiovascular male mortality in all the analysed age groups.

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REFERENCES

1. World Health Organization. Causes of death 2008: Data sources and methods [Internet]. Geneva: The Organization; 2011 [cited 2015 Jan 15]. Available from: http://www.who.int/healthinfo/global_burden_disease/cod_2008_sources_methods.pdf.
2. World Health Organization. Noncommunicable diseases. Country profiles 2011 [Internet]. Geneva: The Organization;

2011 [cited 2015 Jan 21]. Available from: http://www.who.int/nmh/publications/ncd_profiles_report.pdf.
3. World Health Organization. Global health risks: Mortality and burden of disease attributable to selected major risks [Internet]. Geneva: The Organization; 2009 [cited 2015 Feb 3]. Available from: http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf.
4. World Health Organization. Global recommendations on physical activity for health [Internet]. Geneva: The Organization; 2010 [cited 2015 Jan 27]. Available from: http://www.who.int/dietphysicalactivity/global-PA-recs-2010.pdf.
5. Nocon M, Hiemann T, Müller-Riemenschneider F, Thalau F, Roll S, Willich SN. Association of physical activity with all-cause and cardiovascular mortality: A systematic review and meta-analysis. Eur J Cardiovasc Prev Rehabil. 2008;15(3):239–46, http://dx.doi.org/10.1097/HJR.0b013e3282f55e09.
6. Reddigan JI, Ardern CI, Riddell MC, Kuk JL. Relation of physical activity to cardiovascular disease mortality and the influence of cardiometabolic risk factors. Am J Cardiol. 2011;108(10):1426–3, http://dx.doi.org/10.1016/j.amjcard.2011.07.005.
7. Kodama S, Tanaka S, Heianza Y, Fujihara K, Horikawa C, Shimano H, et al. Association between physical activity and risk of all-cause mortality and cardiovascular disease in patients with diabetes: A meta-analysis. Diabetes Care. 2013;36(2):471–9, http://dx.doi.org/10.2337/dc12-0783.
8. Shortreed SM, Peeters A, Forbes AB. Estimating the effect of long-term physical activity on cardiovascular disease and mortality: Evidence from the Framingham Heart Study. Heart. 2013;99(9):649–54, http://dx.doi.org/10.1136/heartjnl-2012-303461.
9. Savela S, Koistinen P, Tilvis RS, Strandberg AY, Pitkälä KH, Salomaa VV, et al. Leisure-time physical activity, cardiovascular risk factors and mortality during a 34-year follow-up in men. Eur J Epidemiol. 2010;25(9):619–25, http://dx.doi.org/10.1007/s10654-010-9483-z.
10. Mathieu RA IV, Powell-Wiley TM, Ayers CR, McGuire DK, Khera A, Das SR, et al. Physical activity participation, health perceptions, and cardiovascular disease mortality in a multiethnic population: The Dallas Heart Study. Am Heart J. 2012;163(6):1037–40, http://dx.doi.org/10.1016/j.ahj.2012.03.005.
11. Cicero AF, d'Addato S, Santi F, Ferroni A, Borghi C. Leisure-time physical activity and cardiovascular disease mortality: The Brisighella Heart Study. J Cardiovasc Med. 2012;13(9):559–64, http://dx.doi.org/10.2459/JCM.0b013e3283516798.
12. Andersen LB, Schnohr P, Schroll M, Hein HO. All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. Arch Intern Med. 2000;160(11):1621–8, http://dx.doi.org/10.1001/archinte.160.11.1621.
13. Li J, Siegrist J. Physical activity and risk of cardiovascular disease – A meta-analysis of prospective cohort studies. Int J Environ Res Public Health. 2012;9(2):391–407, http://dx.doi.org/10.3390/ijerph9020391.
14. Johansson S, Rosengren A, Tsipogianni A, Ulvenstam G, Wiklund I, Wilhelmsen L. Physical inactivity as a risk factor for primary and secondary coronary events in Göteborg, Sweden. Eur Heart J. 1988;9 Suppl L:8–19, http://dx.doi.org/10.1093/eurheartj/9.suppl_L.8.
15. Hu GC, Chien KL, Hsieh SF, Chen CY, Tsai WH, Su TC. Occupational versus leisure-time physical activity in reducing cardiovascular risks and mortality among ethnic Chinese adults in Taiwan. Asia Pac J Public Health. 2014;26(6):604–13, http://dx.doi.org/10.1177/1010539512471966.
16. Hamer M, Chida Y. Active commuting and cardiovascular risk: A meta-analytic review. Prev Med. 2008;46(1):9–13, http://dx.doi.org/10.1016/j.ypmed.2007.03.006.
17. Kwaśniewska M, Kaczmarczyk-Chałas K, Pikala M, Broda G, Kozakiewicz K, Pająk A, et al. Commuting physical activity and prevalence of metabolic disorders in Poland. Prev Med. 2010;51(6):482–7, http://dx.doi.org/10.1016/j.ypmed.2010.09.003.

18. Drygas W, Kwaśniewska M, Kaleta D, Pikala M, Bielecki W, Głuszek J, et al. Epidemiology of physical inactivity in Poland: Prevalence and determinants in a former communist country in socioeconomic transition. Public Health. 2009;123(9): 592–7, http://dx.doi.org/10.1016/j.puhe.2009.08.004.
19. Sawyer S. Nonparametric survival analysis: Cox-Mantel tests and permutation tests [Internet]. Washington University; 2005 [cited 2015 Jan 15]. Available from: http://www.math.wustl.edu/~sawyer/handouts/survrank.pdf.
20. Franco OH, Wong YL, Kandala N-B, Ferrie JE, Dorn JM, Kivimäki M, et al. Cross-cultural comparison of correlates of quality of life and health status: The Whitehall II Study (UK) and the Western New York Health Study (US). Eur J Epidemiol. 2012;27:255–65, http://dx.doi.org/10.1007/s10654-012-9664-z.
21. Petersen CB, Eriksen L, Tolstrup JS, Søgaard K, Grønbæk M, Holtermann A. Occupational heavy lifting and risk of ischemic heart disease and all-cause mortality. BMC Public Health. 2012;12:1070, http://dx.doi.org/10.1186/1471-2458-12-1070.
22. Fransson E, de Faire U, Ahlbom A, Reuterwall C, Hallqvist J, Alfredsson L. The risk of acute myocardial infarction: Interactions of types of physical activity. Epidemiology. 2004;15(5):573–82, http://dx.doi.org/10.1097/01.ede.0000134865.74261.fe.
23. Wennberg P, Lindahl B, Hallmans G, Messner T, Weinhall L, Johanson L, et al. The effects of commuting activity and occupational and leisure time physical activity on risk of myocardial infarction. Eur J Cardiovasc Prev Rehabil. 2006;13(6):924–30, http://dx.doi.org/10.1097/01.hjr.0000239470.49003.c3.
24. Holtermann A, Marott JL, Gyntelberg F, Søgaard K, Suadicani P, Mortensen OS, et al. Occupational and leisure time physical activity: Risk of all-cause mortality and myocardial infarction in the Copenhagen City Heart Study. A prospective cohort study. BMJ Open. 2012;2(1):e000556, http://dx.doi.org/10.1136/bmjopen-2011-000556.
25. Holtermann A, Marott JL, Gyntelberg F, Søgaard K, Suadicani P, Mortensen OS, et al. Does the benefit on survival from leisure time physical activity depend on physical activity at work? A prospective cohort study. PLoS One. 2013;8(1):e54548, http://dx.doi.org/10.1371/journal.pone.0054548.
26. Wilmot EG, Edwardson CL, Achana FA, Davies MJ, Gorely T, Gray LJ, et al. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: Systematic review and meta-analysis. Diabetologia. 2012;55(11):2895–905, http://dx.doi.org/10.1007/s00125-012-2677-z.