Association Between Cardiovascular Fitness and Metabolic Syndrome Among American Workers

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Objective: To explore the association between cardiovascular fitness and metabolic syndrome across occupational groups using a nationally representative sample of the US population. **Methods:** Respondents aged 18 to 49 years from the 1999 to 2004 National Health and Nutrition Examination Survey were evaluated for cardiovascular fitness and classified with regard to metabolic syndrome. Comparisons were made across 40 occupational categories. **Results:** For all occupations with and without metabolic syndrome, the estimated maximal oxygen consumption (Vo_{2max}) was 38.8 mL/kg/min (standard error = 0.5) and 41.1 mL/kg/min (standard error = 0.2), respectively. The estimated Vo_{2max} was higher for those without metabolic syndrome for most occupational groups, particularly for sales supervisors and proprietors, sales representatives, finance, business, and commodities, and freight, stock, and material movers. **Conclusions:** Low estimated Vo_{2max} among workers with metabolic syndrome can be addressed, in part, by workplace interventions designed to increase fitness. This study identifies priority occupational groups for these interventions.

Learning Objectives

- Become familiar with emerging evidence suggesting that declines in occupational physical activity may contribute to poor health outcomes.
- Summarize the new findings on the relationship between cardiovascular fitness (CVF) and metabolic syndrome, across 40 occupational categories.
- Discuss the implications for workplace interventions to increase fitness, including priority occupational groups.

Metabolic syndrome is a constellation of physiologic measures, which represent risk factors that promote atherosclerosis and increase the risk of cardiovascular disease. According to the National Cholesterol Education Program's Adult Treatment Panel III (NCEP/ATPIII), metabolic syndrome can be diagnosed if at least three of the following criteria are met: (1) waist circumference more than 102 cm in men or more than 88 cm in women; (2) fasting glucose 110 mg/dL or more or receiving treatment for diabetes; (3) high-density lipoprotein cholesterol less than 40 mg/dL in men or less than 50 mg/dL in women; (4) blood pressure 130/85 mm Hg or more or receiving treatment for hypertension; and (5) triglycerides 150 mg/dL or more.[1,2] Using data from the National Health and Nutrition Examination Survey (NHANES), the Centers for Disease Control and Prevention estimated that 34% of the population aged 20 years and more met the criteria for metabolic syndrome from 2003 to 2006. The prevalence of metabolic syndrome increases with age and with increasing body weight in the US population.[3] Furthermore, the burden of health care costs is significantly higher among individuals with metabolic syndrome,[4–6] with one study reporting a doubling of annual medical costs compared with those with no risk factors.[7] Thus, the United States faces serious financial consequences as the population continues to age and as obesity levels rise.

The benefits of regular physical activity are well established and include improved weight management, lipid profiles, and blood pressure and decreased risk of various diseases and mortality.[8,9] Furthermore, improved cardiovascular fitness (CVF) as measured by the standard of maximal oxygen consumption (Vo_{2max}), expressed in milliliters of oxygen/kilogram of body weight/minute (mL/kg/min), protects against cardiovascular disease mortality and morbidity.[8,10] The NCEP/ATPIII supports the adoption of healthy lifestyle habits (eg, weight management, exercise, and diet) as a population method of reducing metabolic risk factors and thereby cardiovascular disease risk.[1] Participants in the HERITAGE Family Study who engaged in a 20-week aerobic exercise program were found to have improved Vo_{2max}, with a reduction in the number of individuals classified with metabolic syndrome.[11] Nevertheless, global rates of physical activity are declining, as one-third of the world's population is estimated to be insufficiently active.[12]

Although much of the literature has traditionally examined recreational physical activity trends, emerging evidence indicates that declining occupational physical activity contributes to poor health outcomes. From 1960 to 2008, the prevalence of moderate activity occupations significantly decreased by 28% among US workers.[13] Using 1999 to 2004 NHANES data, the overall age-adjusted prevalence of metabolic syndrome among US workers was found to be 20.6%.[14] Obese employees and individuals in food preparation and service, farm operators, managers, and supervisors, and health service occupations had the highest prevalence of metabolic syndrome.[14] Similarly, individuals in sedentary occupations (eg, sales and retail services, food preparation, and miscellaneous administrative support) were found to have a greater percentage of workers with low CVF compared with other occupations.[10] This evidence supports the impact of occupational activity on CVF and the prevalence of metabolic syndrome; however, it is unknown whether CVF and metabolic syndrome are associated with each other across occupation groups. Thus, the objective of this study was to assess CVF levels among US workers with and without metabolic syndrome.

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METHODS

Data Source

The 1999 to 2004 NHANES, a multistage-stratified survey examining a sample of the US civilian noninstitutionalized population aged 18 to 49 years, collected a substantial amount of data regarding the health status of volunteers using a combination of interviews and physical examinations.[15] Specifically, fasting lipids and glucose were measured through standard blood sampling. In addition, waist circumference, blood pressure, and diabetes status were assessed, allowing the determination of the presence of metabolic syndrome. Beginning in 2001, volunteers were given the Physical Activity Questionnaire to determine their daily physical activity and sedentary behaviors. Cardiovascular fitness using a submaximal Vo_2 test was conducted from 1999 to 2004. Included in this study were the 3211 NHANES participants who were working, completed Vo_{2max} testing, and were evaluated for the presence of metabolic syndrome.

Cardiovascular Fitness Assessment

The NHANES assigned participants to one of the eight treadmill protocols, each involving a 2-minute warm-up, two 3-minute exercise periods, and a 2-minute cool-down stage. Protocol matching was based on each participant's sex, age, body mass index, and self-reported activity level. Oxygen consumption at 75% of the participant's age-predicted maximum heart rate was measured. Assuming a linear relationship between heart rate and oxygen consumption, investigators estimated Vo_{2max} by extrapolation.[16] According to data from the Aerobics Center Longitudinal Study, estimated Vo_{2max} was categorized on the basis of cut points for sex and age. Low, moderate, and high CVFs were defined as estimated Vo_{2max} below the 20th percentile, between the 20th and 59th percentiles, and equal to or above the 60th percentile, respectively, compared with Aerobics Center Longitudinal Study data on the same sex and age group.[10,15]

Metabolic Syndrome Categorization

Participants were sorted into "metabolic syndrome" ($n = 365$) or "no metabolic syndrome" ($n = 2846$) on the basis of the presence of at least three of the ATPIII criteria as listed above. This definition has been used in previously published NHANES analyses.[1,14]

Occupational Categorization

Work status (paid and unpaid) for the week before study participation was determined for all NHANES subjects who were 18 to 49 years of age. Participants were then sorted into 40 standardized occupational categories as seen in Table 1.

Physical Activity Categorization

The Physical Activity Questionnaire section of the NHANES was administered in person by a trained interviewer. Respondents were asked about their frequency of moderate and vigorous activity performed within the past 30 days.[17]

Statistical Analysis

Data from the 1999 to 2000, 2001 to 2002, and 2003 to 2004 NHANES cycles were combined for this study.[18] All analyses were conducted using SAS 9.21 (SAS Institute, Inc, Cary, NC). Sociodemographic variables of interest, including sex, age, ethnicity/race, education, body mass index, daily level of physical activity, and activity level in the previous month, were determined for the population (Table 2). The mean Vo_{2max} and standard error were calculated using SAS-Callable SUDAAN 10.0 collapsed across sex and by presence of metabolic syndrome (Table 1). For each occupational category in the analysis, pooled t tests were run comparing Vo_{2max} in participants with metabolic syndrome with those without (Table 1). A $P < 0.05$ was chosen to represent a significant difference between the two groups.

Institutional Oversight

This study was approved by the Institutional Review Board for Human Subjects.

RESULTS

Table 2 shows characteristics of the NHANES sample of adult workers, as previously reported by our group.[10] Participants with a body mass index in the overweight or obese category made up 56.8% of the study population. Only 32.4% of subjects reported taking the stairs and/or lifting light or heavy loads on a daily basis, and less than half had engaged in vigorous activity in the previous month.

Table 1 shows Vo_{2max} and standard error for all subjects characterized with or without metabolic syndrome for different occupations. Statistical significance was achieved for all occupations collapsed together and for six specific occupational categories. For all occupations, participants with metabolic syndrome had a significantly lower Vo_{2max} than those without metabolic syndrome (38.78 ± 0.50 vs 41.07 ± 0.19; $P < 0.001$). For supervisors and proprietors, sales occupations (32.71 ± 2.14 vs 43.13 ± 1.30; $P < 0.001$), sales representatives, finance, business, and commodities except retail (34.09 ± 1.46 vs 40.86 ± 1.22; $P < 0.001$), freight, stock, and material movers, hand (36.44 ± 1.73 vs 45.78 ± 1.34; $P < 0.001$), teachers (33.58 ± 2.31 vs 39.21 ± 0.94; $P = 0.04$), and other transportation and material moving occupations (37.70 ± 1.50 vs 43.29 ± 1.19; $P = 0.05$), participants with metabolic syndrome had a significantly lower Vo_{2max} than subjects without metabolic syndrome, respectively. Conversely, for material recording, scheduling, and distributing clerks, participants with metabolic syndrome had a significantly higher Vo_{2max} than those without metabolic syndrome (47.00 ± 5.02 vs 38.33 ± 1.25; $P = 0.02$). Participants with metabolic syndrome had a lower Vo_{2max} than those without metabolic syndrome in 31 of the 39 occupations (two analyses could not be calculated because of lack of subjects).

DISCUSSION

We have previously investigated the relationships between (1) metabolic syndrome and occupation and (2) CVF and occupation. We noted that 20% of American workers met the criteria for metabolic syndrome,[14] and 52% of those employed in the United States had low to moderate CVF.[10] In addition, these associations were shown to vary across occupational groups. A paucity of data exists regarding the relationship between metabolic syndrome and CVF, although two studies have demonstrated a significant relationship between low level of fitness and a greater risk of metabolic syndrome.[19,20] Even less is known about the association between metabolic syndrome and CVF among people who are actively employed. To our knowledge, this study is the first to analyze the relationship between CVF and metabolic syndrome among a population-based group of American workers.

Overall, we showed that US workers with metabolic syndrome had lower CVF compared with those without metabolic syndrome. Estimated Vo_{2max} was significantly higher among workers with metabolic syndrome in only one occupational category. Another study examined the relationship between CVF and metabolic syndrome in a sample of US male executives and found that those in the lowest quartile of fitness had a fivefold increased risk of having metabolic syndrome after adjusting for age and body mass index.[21] Although not conducted specifically to determine the relationship between CVF, metabolic syndrome, and occupational status, these authors noted the implications of the prevalence of metabolic syndrome and poor fitness among corporate executives.

We also found that CVF was generally higher among occupations with greater activity levels (eg, freight, stock, and material movers, hand, other helpers) and without metabolic syndrome (eg, farm and nursery workers). Unfortunately, in the latter half of the 1900s, the US workforce experienced a shift in occupational physical

TABLE 1. VO_{2max} in Subjects With and Without Metabolic Syndrome by Occupation Category*

	Metabolic Syndrome		No Metabolic Syndrome		
Occupation	***n***	**Adjusted VO_{2max} ± SE**	***n***	**Adjusted VO_{2max} ± SE**	***P* Value**
All occupations	365	38.78 ± 0.50	2,844	41.07 ± 0.19	0.001
Executive, administrators, and managers	23	38.82 ± 1.88	209	40.90 ± 0.65	0.31
Management-related occupations	6	33.84 ± 2.84	76	38.47 ± 1.08	0.24
Engineers, architects, and scientists	9	40.82 ± 3.77	88	42.99 ± 0.97	0.51
Health diagnosing, assessing, and treating occupations	6	35.84 ± 3.24	67	38.67 ± 1.17	0.49
Teachers	13	33.58 ± 2.31	99	39.21 ± 0.94	0.04
Writers, artists, entertainers, and athletes	4	39.84 ± 3.10	56	41.89 ± 1.49	0.72
Other professional specialty occupations	11	40.95 ± 3.17	59	39.38 ± 1.26	0.63
Technicians and related support occupations	15	37.66 ± 1.43	88	38.74 ± 0.96	0.53
Supervisors and proprietors, sales occupations	11	32.71 ± 2.14	52	43.13 ± 1.30	0.001
Sales representatives, finance, business, and commodities except retail	13	34.09 ± 1.46	60	40.86 ± 1.22	0.001
Sales workers, retail, and personal services	24	39.11 ± 1.73	198	40.19 ± 0.68	0.60
Secretaries, stenographers, and typists	7	35.00 ± 2.65	36	34.82 ± 1.35	0.96
Information clerks	7	34.83 ± 3.63	48	38.62 ± 1.30	0.31
Records processing occupations	10	34.59 ± 3.21	74	35.96 ± 0.83	0.59
Material recording, scheduling, and distributing clerks	7	47.00 ± 5.02	47	38.33 ± 1.25	0.02
Miscellaneous administrative support occupations	16	32.99 ± 2.17	219	37.37 ± 0.72	0.11
Private household occupations	7	35.02 ± 2.52	20	37.96 ± 1.69	0.37
Protective service occupations	9	39.81 ± 2.60	48	40.37 ± 1.11	0.84
Waiters and waitresses	1	27.15	74	41.00 ± 1.03	–
Cooks	8	39.22 ± 4.18	77	42.77 ± 1.55	0.48
Miscellaneous food preparation and service occupations	11	39.90 ± 2.86	68	43.60 ± 1.81	0.43
Health service occupations	10	33.64 ± 1.89	70	36.41 ± 0.93	0.28
Cleaning and building service occupations	13	38.50 ± 3.15	76	39.79 ± 0.98	0.63
Personal service occupations	6	34.64 ± 2.24	68	39.81 ± 0.99	0.13
Farm operators, managers, and supervisors	2	34.51 ± 1.31	8	37.98 ± 2.32	0.50
Farm and nursery workers	3	43.56 ± 6.59	33	44.31 ± 1.61	0.90
Related agricultural, forestry, and fishing occupations	9	47.85 ± 3.13	54	47.89 ± 1.75	0.99
Vehicle and mobile equipment mechanics and repairers	6	38.77 ± 2.85	38	41.33 ± 1.12	0.40
Other mechanics and repairers	14	41.11 ± 1.81	44	44.23 ± 1.58	0.30
Construction trades	12	40.66 ± 2.28	190	45.55 ± 0.69	0.08
Extractive and precision production occupations	11	42.61 ± 3.54	60	41.87 ± 0.98	0.84
Textile, apparel, and furnishings machine operators	3	56.56 ± 11.10	12	43.78 ± 3.24	0.15
Machine operators, assorted materials	15	41.88 ± 1.31	72	41.43 ± 2.01	0.82
Fabricators, assemblers, inspectors, and samplers	10	44.53 ± 4.63	59	40.53 ± 1.19	0.42
Motor vehicle operators	13	42.67 ± 3.07	89	42.52 ± 1.09	0.96
Other transportation and material moving occupations	6	37.70 ± 1.50	30	43.29 ± 1.19	0.05
Construction laborers	3	49.19 ± 4.62	38	50.04 ± 2.00	0.91
Laborers, except construction	0	–	23	44.66 ± 2.39	–
Freight, stock, and material movers, hand	7	36.44 ± 1.73	64	45.78 ± 1.34	0.001
Other helpers, equipment cleaners, hand packagers, and laborers	4	45.39 ± 8.35	55	45.66 ± 1.73	0.97

*Some estimates do not meet the National Center for Health Statistics standard of reliability or precision because the sample size is less than 30 and/or the sample size is less than 30 and has a relative standard error 30% or more.

SE, standard error.

TABLE 2. Sociodemographic Characteristics of the 1999 to 2004 NHANES United States Adult Worker Study Population

Variable	Category	*n* (%)
Sex	Male	1,895 (56.5)
	Female	1,459 (43.5)
Age, yrs	18–19	642 (19.1)
	20–24	522 (15.6)
	25–29	445 (13.3)
	30–34	466 (13.9)
	35–39	473 (14.1)
	40–44	439 (13.1)
	45–49	367 (10.9)
Ethnicity/race	White	1,505 (44.9)
	Black	686 (20.5)
	Hispanic	1,077 (32.1)
	Other	86 (2.6)
Education	Less than high school	804 (24.0)
	Completed high school	905 (27.0)
	More than high school	1,645 (49.0)
Body mass index	Normal or underweight (<25)	1,445 (43.2)
	Overweight (25.0–29.9)	1,056 (31.6)
	Obese or extremely overweight (≥30)	843 (25.2)
Daily level of physical activity	Mostly sitting	602 (18.0)
	Stands/walks	1,667 (49.7)
	Stairs/lifts light or heavy loads	1,085 (32.4)
Activity level in previous month	Neither vigorous or moderate	997 (29.7)
	Some moderate	712 (21.2)
	Some vigorous	1,645 (49.1)

activity. In 1950, approximately 30% more workers were employed in high-activity occupations, such as agricultural employment; by 2000, the number of workers in low-activity occupations compared with high-activity occupations had approximately doubled.[22] Given that fewer Americans are now working in jobs that require manual exertion, the need for leisure time physical activity and its subsequent impact on both CVF and the risk of metabolic syndrome and its associated chronic diseases is even more important.[19,20]

The increasing prevalence of metabolic syndrome and declining CVF among the US workforce may also contribute to rising health-related expenses and costs to employers.[23] In our analysis, individuals with metabolic syndrome had lower CVF, which could contribute to loss of productivity at work because of higher rates of absenteeism (ie, time away from work because of injury or illness) and presenteeism (ie, reduced productivity from employees who attend work while ill), respectively.[24] Thus, employers should rely more on worksite health promotion (WHP) programs to address employee health lifestyle risks and reduce health care costs.[25] Many WHP programs exist with a focus on the primary prevention of disease among currently healthy employees, disease risk reduction among employees with high risk lifestyle practices, and disease management among employees with a chronic disease such as diabetes.[26,27] Nevertheless, barriers to adopting WHP programs continue to exist among both small and large employers. Our results can be utilized by employers in higher risk occupational categories (eg, supervisors and proprietors and sales occupations) to inform the implementation of WHP and prevention programs among employees with metabolic syndrome.

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