Cardiovascular Fitness Levels Among American Workers

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Objective: To explore cardiovascular fitness in 40 occupations using a nationally representative sample of the US population. **Methods:** Respondents aged 18 to 49 years ($N = 3354$) from the 1999 to 2004 National Health and Nutrition Examination Survey were evaluated for cardiovascular fitness and classified into low, moderate, and high levels. Comparisons were made among occupations. **Results:** Of all the US workers, 16% had low, 36% moderate, and 48% high cardiovascular fitness. Administrators, health occupations, wait staff, personal services, and agricultural occupations had a lesser percentage of workers with low cardiovascular fitness compared with all others. Sales workers, administrative support, and food preparers had a higher percentage of workers with low cardiovascular fitness compared with all others. **Conclusions:** Cardiovascular fitness varies significantly across occupations, and those with limited physical activity have higher percentages of low cardiovascular fitness. Workplace strategies are needed to promote cardiovascular fitness among high-risk occupations.

Many Americans are suffering from the spectrum of coronary artery and cardiovascular diseases (CAD/CVD). Collectively, these diseases are the number one killer responsible for 30% of all global deaths, which was approximately 17.5 million deaths in 2005.[1–3] The comorbid conditions associated with CAD/CVD, such as obesity, diabetes, and cardiometabolic syndrome, have emerged as widespread epidemics crippling the United States and many other parts of the world.[4–11] CAD/CVD and these comorbid conditions warrant further study for causative factors and preventive strategies, given that these epidemics predict early death and disability.

A physically active lifestyle and a moderate to high degree of cardiovascular fitness (CVF) have been associated with health benefits that include reducing (1) risk factors for CAD/CVD and diabetes (eg, hypertension, obesity, hyperglycemia, and hyperlipidemia) and (2) overall morbidity and mortality.[12–14] Moreover, CVF, as measured by the internationally recognized standard of maximum oxygen consumption (VO_2max), expressed in milliliters (mL) of oxygen/kilogram (kg) of bodyweight/minute (min), is a better predictor of CAD/CVD risk compared to self-reported physical activity levels.[15] A recent meta-analysis determined that a higher level of CVF was related to lower risk of all-cause mortality and CAD/CVD,[16] whereas low CVF has been shown to be a significant modifiable risk factor for many diseases and untimely death.[17] Population-level findings also reveal that CVF is inversely related to CAD/CVD risk.[18,19] Thus, CVF is a key characteristic to consider relative to morbidity and mortality from CAD/CVD and other comorbid conditions and is superior to self-reported physical activity levels.

A paucity of data exists examining the relationship between CVF and occupation with few studies making comparisons between occupation categories. A study of healthy men in sedentary occupations (ie, professional, technical, and administrative workers) in Singapore found that those who were regular exercisers had significantly higher VO_2max (40.9 mL/kg/min) compared with their nonexercising counterparts (34.3 mL/kg/min).[20] The regular exercisers had VO_2max values that approximated the ability to perform heavy physical work. In a similar study, VO_2max values obtained from submaximal bicycle ergometry and other cardiovascular risk factors were assessed among women employees in the United States.[21] In this study, academic faculty had the highest average VO_2max (29.1 mL/kg/min), followed by registered nurses and nursing assistants (both 27.0 mL/kg/min) and telephone personnel (22.4 mL/kg/min); however, even among the academic faculty, over 40% were classified as having below-average CVF levels.[21] A recent study found a mean VO_2max of 46.6 mL/kg/min among firefighters, but 25% of the sample were unable to attain a minimally acceptable level of CVF according to the Bruce treadmill protocol.[22] Fifteen percent of the sample met diagnostic criteria for cardiometabolic syndrome, which was significantly and inversely related to CVF.[22]

Although the aforementioned studies have reported CVF levels among specific occupation groups, it is virtually unknown how CVF compares across multiple occupations. In addition, these data suggest an overall low-to-moderate CVF level among these occupation groups, which may portend a greater risk of CAD/CVD and other comorbidities, given the links found between poor fitness and incidence of disease. CVF data across many occupations are needed to understand if these trends are indicative of poor fitness levels on a wider scale. Such information can also be used to identify worker groups that are at particular risk of CAD/CVD for the purpose of creating workplace fitness and other health promotion programs. Thus, the objective of this study was to assess CVF levels among employees in 40 different occupation categories using a nationally representative sample of the United States population and to examine how those fitness levels compared to standard CVF recommendations.

METHODS

Data Source

Participants included adults aged 18 years or more from the 1999 to 2004 National Health and Nutrition Examination Survey (NHANES), a stratified multistage probability sample of the United States civilian noninstitutionalized population. NHANES participants underwent a physical examination that included an assessment of CVF by estimating VO_2max.[23,24] Participants with serious medical conditions, certain medications, physical limitations, and irregular heart rate (HR) were excluded from the estimated VO_2max

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assessment. VO_2max was estimated by extrapolation using measured HR responses to prescribed exercise workloads assuming a linear relationship between HR and oxygen consumption during exercise. On the basis of sex, age, body mass index (BMI), and self-reported level of physical activity, participants were assigned to one of eight treadmill protocols. The goal of the protocol was to elicit a 75% age-predicted maximum HR by the end of the test. Each protocol included a 2-minute warm-up, two 3-minute exercise stages, and a 2-minute cool-down. Estimated VO_2max was then categorized based on cut-points for sex and age and according to data from the Aerobics Center Longitudinal Study.[23,25] Low levels of CVF were defined as estimated VO_2max below the 20th percentile of the Aerobics Center Longitudinal Study data on the same sex and age group. Moderate levels of fitness were defined as a value between the 20th and 59th percentile. High levels of CVF were defined as being equal to or above the 60th percentile. Employment status (paid and unpaid) for participants aged 18 to 49 years was based on self-report during the 1 week prior to the NHANES assessment. Individuals were categorized into 1 of 40 standardized occupation categories. This analysis was approved by the University of Miami institutional review board for human subjects.

Statistical Analysis

Survey variables from the 1999 to 2000, 2001 to 2002, and 2003 to 2004 NHANES cycles were merged for analysis.[26] Frequency and descriptive statistics were calculated on all sociodemographic variables of interest, including sex, age, ethnicity/race, education, BMI, daily level of physical activity, and activity level in previous month. Data management and sample size and percentage computations (Table 1) were performed using SAS 9.21 (SAS Institute, Inc, Cary, NC). The mean VO_2max, percent fitness levels, and standard errors (SE) in Tables 2 and Tables 3 were computed using SAS-Callable SUDAAN 10.0. Using SUDAAN logistic regression, the percentage of low CVF was compared with the combined percentage of moderate and high CVF of each occupation category to all other occupations. Each regression model was adjusted for age, sex, and the sample design.

TABLE 1. Sociodemographic Characteristics of the 1999–2004 NHANES Study Population of Employed Adults

Variable, Category	*N* (%)
Sex	
Men	1,895 (56.5)
Women	1,459 (43.5)
Age, yr	
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	
<High school	804 (24.0)
Completed high school	905 (27.0)
>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)

RESULTS

A total of 3354 workers aged 18 or more years from the continuous 1999 to 2004 NHANES was used for analysis in this study, representing an approximate annual average of 51 million United States residents, based on the number of participants with a completed VO_2max test. Table 1 shows the sociodemographic characteristics of the sample, including sex, age, ethnicity/race, education, BMI, marital status, daily level of physical activity, and activity level in previous month. Men comprised approximately 57% of the sample, 48% were younger than 30 years of age, 45% were white, non-Hispanic, and 49% had completed more than high school. Overweight or obese (according to BMI) participants made up over 56% of the sample, only 32% reported taking the stairs and/or lifting light or heavy loads on a daily basis, and 30% had not engaged in vigorous or moderate activity in the previous month.

Table 2 shows the survey-adjusted means and SE for estimated VO_2max by occupation for the total sample and by sex. For all occupations, the mean estimated VO_2max levels for the total sample, men, and women were 40.4 mL/kg/min (SE = 0.3), 43.8 mL/kg/min (SE = 0.3), and 35.9 mL/kg/min (SE = 0.3), respectively. The lowest average estimated VO_2max value was found for farm operators, managers, and supervisors in both men (M = 37.7 mL/kg/min, SE = 1.8) and women (M = 27.4 mL/kg/min, SE = 0.9). The highest average estimated VO_2max value for men was found for construction laborers (M = 49.5 mL/kg/min, SE = 2.2). In women, the highest average estimated VO_2max value was found for construction trades (M = 44.9 mL/kg/min, SE = 6.4).

Table 3 shows the survey-adjusted percentages and SE for the low, moderate, and high CVF groups by occupation. Overall, all occupations had 16.1% (SE = 0.9), 35.5% (SE = 1.2), and 48.4% (SE = 1.5) of workers in the low, moderate, and high CVF categories, respectively. Approximately 7% of farm and nursery workers, related agricultural, forestry, and fishing occupations, and health diagnosing, assessing, and treating occupations had low CVF. Miscellaneous food preparation and service occupations, secretaries, stenographers, and typists, sales workers, retail, and personal services, farm operators, managers, and supervisors, and fabricators, assemblers, inspectors, and samplers had at least 25% of their workers with low CVF levels.

Farm operators, managers, and supervisors, secretaries, stenographers, and typists, vehicle and mobile equipment mechanics and repairers, and protective service occupations had the lowest prevalence (<32%) of high CVF. At least 59% of workers of engineers, architects, and scientists, private household occupations, construction laborers, and related agricultural, forestry, and fishing occupations had high CVF.

Following adjustment for age, sex, and survey design, executive, administrators, and managers (Wald $\chi^2_1 = 7.2$, $P = 0.008$;

TABLE 2. Estimated VO_2max by Occupation Category Among Adult Participants of the 1994-2004 NHANES

Occupation	Estimated Average Annual Number of US Workers*	Total Sample			Men			Women		
		N	Adjusted Mean ± SE	95% CI	*N*	Adjusted Mean ± SE	95% CI	*N*	Adjusted Mean ± SE	95% CI
All occupations	51,325,181	3,354	40.4 ± 0.3	39.8–41.0	1,895	43.8 ± 0.3	43.2–44.4	1,459	35.9 ± 0.3	35.3–36.6
Executive, administrators, and managers	4,853,423	236	41.0 ± 0.7	39.6–42.5	134	43.9 ± 0.8	42.2–45.6	102	36.8 ± 0.8	35.2–38.4
Management-related occupations	1,616,183	89	39.1 ± 1.2	36.7–41.6	37	42.8 ± 1.8	39.1–46.5	52	36.0 ± 1.7	32.6–39.3
Engineers, architects, and scientists	2,075,309	99	43.6 ± 0.9	41.7–45.4	76	45.2 ± 1.0	43.2–47.1	23†	36.0 ± 1.7	32.6–39.5
Health diagnosing, assessing, and treating occupations	1,818,977	73	39.0 ± 1.4	36.3–41.8	16†	45.0 ± 1.7	41.6–48.4	57	37.0 ± 1.4	34.1–39.8
Teachers	2,215,864	118	39.4 ± 1.3	36.8–41.9	36	45.3 ± 2.3	40.8–49.9	82	37.0 ± 1.2	34.5–39.5
Writers, artists, entertainers, and athletes	1,141,704	62	41.2 ± 1.6	38.1–44.3	39	44.3 ± 2.2	39.8–48.8	23†	36.4 ± 1.4	33.6–39.1
Other professional specialty occupations	1,487,826	73	39.2 ± 1.0	37.3–41.1	36	43.4 ± 1.5	40.3–46.5	37	34.6 ± 1.2	32.1–37.0
Technicians and related support occupations	1,913,926	104	38.8 ± 1.0	36.7–40.8	51	42.3 ± 1.3	39.7–44.8	53	35.7 ± 1.0	33.7–37.6
Supervisors and proprietors, sales occupations	1,235,651	68	40.6 ± 1.2	38.2–43.0	40	41.8 ± 1.0	39.8–43.8	28†	39.0 ± 2.4	34.2–43.8
Sales representatives, finance, business, and commodities except retail	1,647,287	77	39.3 ± 1.1	37.1–41.6	49	42.6 ± 1.3	40.1–45.2	28†	32.9 ± 1.0	30.9–34.9
Sales workers, retail, and personal services	2,537,065	237	39.0 ± 0.9	37.2–40.7	91	44.3 ± 1.1	42.2–46.5	146	35.1 ± 1.0	33.1–37.1
Secretaries, stenographers, and typists	785,442	45	34.0 ± 1.1	31.9–36.2	4†	40.9 ± 1.8	37.2–44.7	41	33.4 ± 1.0	31.3–35.5
Information clerks	964,964	58	37.2 ± 1.5	34.2–40.3	13†	43.5 ± 2.1	39.4–47.7	45	35.7 ± 1.7	32.4–39.0
Records processing occupations	1,512,033	86	35.7 ± 0.9	33.9–37.5	15†	38.3 ± 1.6	35.1–41.4	71	35.3 ± 1.0	33.3–37.3
Material recording, scheduling, and distributing clerks	728,622	54	39.0 ± 1.5	35.9–42.0	29†	41.5 ± 1.4	38.7–44.4	25†	36.6 ± 2.5	31.5–41.6
Miscellaneous administrative support occupations	3,429,960	242	37.2 ± 0.9	35.4–38.9	63	44.3 ± 1.8	40.6–48.0	179	35.0 ± 0.9	33.1–36.9
Private household occupations	409,511	29†	36.6 ± 1.4	33.8–39.3	2†	43.1 ± 0.0	43.1–43.1	27†	36.2 ± 1.4	33.3–39.0
Protective service occupations	990,143	61	39.9 ± 1.1	37.8–42.1	46	42.3 ± 1.0	40.2–44.5	15†	31.6 ± 1.0	29.6–33.5
Waiters and waitresses	1,087,385	80	38.9 ± 1.0	36.9–40.9	25†	43.2 ± 1.9	39.5–47.0	55	37.2 ± 1.0	35.2–39.1
Cooks	916,820	90	45.7 ± 3.6	38.5–52.9	68	49.4 ± 4.5	40.4–58.5	22†	34.0 ± 1.6	30.7–37.3
Miscellaneous food preparation and service occupations	935,461	83	40.0 ± 1.5	36.9–43.1	39	44.0 ± 2.2	39.6–48.4	44	36.7 ± 2.0	32.7–40.7
Health service occupations	981,524	83	36.9 ± 0.9	35.1–38.7	14†	41.5 ± 2.8	35.8–47.2	69	35.7 ± 0.8	34.0–37.4
Cleaning and building service occupations	1,043,370	95	39.0 ± 1.1	36.8–41.1	45	43.3 ± 1.2	41.0–45.7	50	35.1 ± 1.4	32.4–37.9
Personal service occupations	1,059,154	80	39.6 ± 1.1	37.3–41.9	28†	45.9 ± 0.9	44.1–47.6	52	36.1 ± 1.5	33.0–39.1
Farm operators, managers, and supervisors	236,159	11†	35.6 ± 2.1	31.5–39.8	9†	37.7 ± 1.8	34.0–41.4	2†	27.4 ± 0.9	25.7–29.2
Farm and nursery workers	292,619	36	43.5 ± 0.9	41.8–45.3	25†	46.2 ± 1.1	43.9–48.5	11†	38.1 ± 1.9	34.3–41.9
Related agricultural, forestry, and fishing occupations	741,459	67	46.7 ± 2.3	42.2–51.3	60	47.8 ± 2.4	43.0–52.6	7†	39.7 ± 2.0	35.8–43.7
Vehicle and mobile equipment mechanics and repairers	680,185	44	39.5 ± 1.1	37.2–41.8	43	39.5 ± 1.2	37.2–41.9	1†	36.0 ± 0.0	36.0–36.0
Other mechanics and repairers	924,823	60	42.8 ± 1.4	40.0–45.7	58	43.0 ± 1.4	40.1–45.8	2†	29.7 ± 1.9	25.9–33.5
Construction trades	3,030,737	210	44.1 ± 0.6	42.8–45.3	206	44.1 ± 0.6	42.9–45.3	4†	44.9 ± 6.4	32.0–57.7
Extractive and precision production occupations	1,243,977	75	41.6 ± 1.1	39.4–43.9	62	42.0 ± 1.4	39.1–44.9	13†	40.0 ± 2.5	35.0–45.0
Textile, apparel, and furnishings machine operators	205,498	15†	45.8 ± 3.7	38.3–53.4	8†	47.2 ± 5.1	36.9–57.4	7†	44.5 ± 5.7	33.0–56.0

(*continues*)

TABLE 2. Estimated VO_2max by Occupation Category Among Adult Participants of the 1994-2004 NHANES (*Continued*)

Occupation	Estimated Average Annual Number of US Workers*	Total Sample			Men			Women		
		N	Adjusted Mean ± SE	95% CI	*N*	Adjusted Mean ± SE	95% CI	*N*	Adjusted Mean ± SE	95% CI
Machine operators, assorted materials	1,190,439	93	41.1 ± 0.6	39.9–42.2	76	41.1 ± 0.7	39.7–42.5	17†	40.8 ± 1.1	38.6–43.1
Fabricators, assemblers, inspectors, and samplers	1,008,093	73	40.5 ± 1.7	37.1–44.0	42	42.9 ± 1.9	39.1–46.6	31	36.4 ± 2.1	32.2–40.7
Motor vehicle operators	1,689,775	107	44.3 ± 1.6	41.2–47.5	98	45.2 ± 1.7	41.8–48.6	9†	33.4 ± 1.8	29.8–37.0
Other transportation and material moving occupations	616,014	38	41.4 ± 0.7	40.1–42.7	37	41.7 ± 0.6	40.4–43.0	1†	33.5 ± 0.0	33.5–33.5
Construction laborers	362,272	41	49.5 ± 2.2	45.2–53.8	41	49.5 ± 2.2	45.2–53.8	0		
Laborers, except construction	323,064	23†	42.9 ± 1.8	39.3–46.6	17†	43.5 ± 1.9	39.6–47.5	6†	39.6 ± 4.6	30.3–48.8
Freight, stock, and material movers, hand	730,436	74	44.2 ± 1.5	41.2–47.2	64	45.0 ± 1.6	41.9–48.2	10†	38.3 ± 0.9	36.5–40.0
Other helpers, equipment cleaners, hand packagers, and laborers	662,024	65	42.9 ± 1.9	39.1–46.8	53	46.1 ± 2.0	42.1–50.2	12†	30.4 ± 1.6	27.2–33.7

*Our estimated population of US workers is lower due to the number of NHANES participants who completed the VO_2max test.
†Estimates do not meet the National Center for Health Statistics standard of reliability or precision because the sample size is <30.

odds ratio [OR] = 0.55, 95% confidence interval [CI] = 0.35–0.86), health diagnosing, assessment, and treating occupations (Wald χ^2_1 = 4.4, P = 0.04; OR = 0.42, 95% CI = 0.18–0.97), waiters and waitresses (Wald χ^2_1 = 4.9, P = 0.03; OR = 0.44, 95% CI = 0.21–0.93), personal service occupations (Wald χ^2_1 = 6.1, P = 0.01; OR = 0.42–95% CI = 0.21–0.85), and related agricultural, forestry, and fishing occupations (Wald χ^2_1 = 4.2, P = 0.04; OR = 0.36, 95% CI = 0.13–0.98) had a smaller percentage of workers with low CVF compared with all other occupations. Sales workers, retail, and personal services (Wald χ^2_1 = 7.3, P = 0.007; OR = 1.89, 95% CI = 1.18–3.02), miscellaneous administrative support occupations (Wald χ^2_1 = 4.8, P = 0.03; OR = 1.54, 95% CI = 1.03–2.30), and miscellaneous food preparation and service occupations (Wald χ^2_1 = 3.9, P = 0.05; OR = 1.96, 95% CI = 0.98–3.92) had a higher percentage of workers with low CVF compared with all other occupations.

DISCUSSION

To our knowledge, this population-based study of American workers is the first to examine CVF, as measured by estimated VO_2max, across 40 different occupation categories. Approximately 16% of all workers had low CVF. For men, the lowest level of mean estimated VO_2max was for farm operators, managers, and supervisors, and the highest levels were for cooks and construction laborers. For women, the lowest average estimated VO_2max value was for farm operators, managers, and supervisors, and the highest values were for textile, apparel, and furnishings machine operators and construction trades. Several occupations had particularly unfit workers according to percentages adjusted by age and sex, including sales workers, retail, and personal services, miscellaneous administrative support occupations, and miscellaneous food preparation and service occupations. Moreover, executive, administrators, and managers, health diagnosing, assessment, and treating occupations, waiters and waitresses, personal service occupations, and related agricultural, forestry, and fishing occupations had the lowest levels of low CVF compared with all other occupations. These findings are consistent with the limited research available for occupation-based studies of CVF, which show a range of estimated VO_2max values from the low 20s mL/kg/min for service and white collar personnel[21] to a higher average VO_2max of 46.6 mL/kg/min in workers engaging in greater on-the-job activity, such as firefighters.[22]

This research team previously explored three other factors related to CAD/CVD by occupation: (1) obesity, (2) self-reported physical activity level, and (3) cardiometabolic syndrome.[27–29] From 1986 to 2002, men workers in the following occupations had the highest rates of obesity: motor vehicle operators, material-moving equipment operators, police and firefighters, other transportation except motor vehicle moving operators, and other protective services employees. For women workers, the highest rates of obesity were among motor vehicle operators, other protective service workers, health services workers, material-moving equipment operators, and cleaning and building services workers.[27] None of these similar occupation groups had noteworthy levels of CVF in this study (neither low nor high). Thus, the theorized relationship between high levels of obesity and low levels of CVF may require further investigation, as few reports have addressed this area in the general population, particularly by occupation category.[30] Also, measuring BMI, compared with actual body fat, introduces error into the relationship, given that BMI does not account for a high level of muscle (or fat-free) mass.[31,32]

Using the National Health Interview Surveys from 1997 to 2004, a previous study by this team found only one-third of men and women workers met recommended leisure-time physical activity levels.[28] In addition, mixed results were found, when leisure-time physical activity levels were measured by occupation groups. The lowest rates of leisure-time physical activity were found in

TABLE 3. Adjusted Percentage of Workers With Low, Moderate, and High Cardiovascular Fitness by Occupation Category

Occupation	Estimated Average Annual Number of US Workers[b]	Low Cardiovascular Fitness			Moderate Cardiovascular Fitness			High Cardiovascular Fitness		
		N	Adjusted % ± SE	95% CI	*N*	Adjusted % ± SE	95% CI	*N*	Adjusted % ± SE	95% CI
All occupations	51,325,181	677	16.1 ± 0.9	14.3–18.0	1,205	35.5 ± 1.2	33.1–38.0	1,472	48.4 ± 1.5	45.5–51.4
Executive, administrators, and managers*	4,853,423	31	8.9 ± 1.7	6.0–13.0	81	35.4 ± 2.9	29.8–41.3	124	55.8 ± 3.3	49.1–62.2
Management-related occupations	1,616,183	21[a]	19.6 ± 5.9	10.3–34.1	28[a]	32.4 ± 6.0	21.6–45.4	40	48.1 ± 5.3	37.5–58.7
Engineers, architects, and scientists	2,075,309	11[a]	9.9 ± 3.2	5.0–18.5	35	31.1 ± 7.1	18.8–46.8	53	59.0 ± 7.2	44.1–72.4
Health diagnosing, assessing, and treating occupations*	1,818,977	8[a]	7.1 ± 2.7	3.2–14.8	24[a]	35.6 ± 5.2	26.0–46.5	41	57.3 ± 5.2	46.7–67.4
Teachers	2,215,864	19[a]	10.3 ± 3.2	5.4–18.8	39	32.6 ± 5.2	23.2–43.7	60	57.0 ± 5.6	45.6–67.8
Writers, artists, entertainers, and athletes	1,141,704	9[a]	12.4 ± 5.4	4.9–27.8	26[a]	36.7 ± 7.7	22.8–53.1	27[a]	51.0 ± 9.2	33.1–68.6
Other professional specialty occupations	1,487,826	11[a]	14.0 ± 4.1	7.6–24.4	32	40.9 ± 7.1	27.7–55.6	30	45.0 ± 7.6	30.5–60.4
Technicians and related support occupations	1,913,926	26[a]	19.9 ± 3.9	13.1–29.0	33	29.8 ± 4.8	21.1–40.3	45	50.3 ± 5.6	39.3–61.3
Supervisors and proprietors, sales occupations	1,235,651	18[a]	20.5 ± 4.8	12.4–31.9	18[a]	30.2 ± 5.3	20.7–41.7	32	49.4 ± 6.2	37.2–61.7
Sales representatives, finance, business, and commodities except retail	1,647,287	12[a]	15.0 ± 5.6	6.8–29.9	33	42.8 ± 7.2	29.3–57.6	32	42.2 ± 6.9	29.3–56.3
Sales workers, retail, and personal services**	2,537,065	83	29.5 ± 4.3	21.5–38.9	65	26.7 ± 3.6	20.2–34.5	89	43.8 ± 3.9	36.1–51.8
Secretaries, stenographers, and typists	785,442	14[a]	27.7 ± 6.9	16.1–43.4	19[a]	44.4 ± 6.7	31.5–58.1	12[a]	27.9 ± 6.9	16.2–43.5
Information clerks	964,964	11[a]	13.2 ± 5.4	5.5–28.4	27[a]	48.0 ± 9.4	30.2–66.2	20[a]	38.8 ± 9.3	22.4–58.2
Records processing occupations	1,512,033	19[a]	15.5 ± 4.1	8.9–25.7	37	37.8 ± 5.9	26.9–50.2	30	46.6 ± 5.7	35.6–58.0
Material recording, scheduling, and distributing clerks	728,622	12[a]	18.5 ± 6.4	8.9–34.7	22[a]	39.2 ± 8.2	24.3–56.3	20[a]	42.3 ± 7.9	27.7–58.4
Miscellaneous administrative support occupations**	3,429,960	72	23.9 ± 3.5	17.6–31.6	88	36.2 ± 3.9	28.8–44.4	82	39.9 ± 4.0	32.2–48.0
Private household occupations	409,511	7[a]	19.6 ± 6.9	9.2–37.1	6[a]	22.0 ± 8.2	9.7–42.5	16[a]	58.4 ± 10.0	38.1–76.3
Protective service occupations	990,143	13[a]	20.1 ± 6.7	9.8–36.8	27[a]	48.2 ± 7.5	33.8–63.0	21[a]	31.6 ± 7.2	19.2–47.4
Waiters and waitresses*	1,087,385	14[a]	10.8 ± 3.5	5.5–20.1	31	45.0 ± 8.0	29.8–61.1	35	44.2 ± 8.2	28.9–60.7
Cooks	916,820	19[a]	19.1 ± 4.3	11.8–29.3	38	32.5 ± 6.2	21.5–46.0	33	48.4 ± 6.6	35.5–61.6
Miscellaneous food preparation and service occupations**	935,461	21[a]	31.4 ± 6.2	20.4–44.9	28[a]	29.8 ± 7.3	17.4–46.1	34	38.8 ± 6.9	26.2–53.2
Health service occupations	981,524	21[a]	16.6 ± 5.1	8.7–29.4	33	43.9 ± 7.0	30.6–58.0	29[a]	39.6 ± 6.0	28.3–52.1
Cleaning and building service occupations	1,043,370	18[a]	14.3 ± 3.8	8.2–23.9	34	39.1 ± 6.2	27.6–51.9	43	46.6 ± 6.5	34.0–59.7
Personal service occupations*	1,059,154	13[a]	8.2 ± 2.6	4.2–15.3	33	35.6 ± 7.9	21.6–52.5	34	56.2 ± 7.9	40.2–71.0
Farm operators, managers, and supervisors	236,159	2[a]	26.6 ± 20.1	4.3–74.3	6[a]	53.7 ± 20.6	17.9–86.1	3[a]	19.7 ± 11.9	5.1–52.9
Farm and nursery workers	292,619	4[a]	6.1 ± 4.3	1.4–22.6	17[a]	42.4 ± 5.5	31.8–53.7	15[a]	51.6 ± 6.1	39.5–63.5
Related agricultural, forestry, and fishing occupations*	741,459	5[a]	6.6 ± 2.8	2.7–15.2	21[a]	28.6 ± 9.0	14.1–49.4	41	64.8 ± 8.4	46.6–79.5
Vehicle and mobile equipment mechanics and repairers	680,185	9[a]	22.4 ± 7.7	10.6–41.2	20[a]	46.5 ± 9.0	29.5–64.3	15[a]	31.1 ± 8.0	17.5–49.0
Other mechanics and repairers	924,823	10[a]	14.2 ± 5.5	6.3–29.0	19[a]	38.7 ± 8.2	24.0–55.8	31	47.1 ± 7.2	33.2–61.5
Construction trades	3,030,737	31	12.9 ± 2.7	8.3–19.4	69	30.5 ± 3.8	23.4–38.5	110	56.7 ± 3.8	48.8–64.2
Extractive and precision production occupations	1,243,977	9[a]	13.3 ± 5.3	5.7–27.9	32	40.0 ± 6.0	28.8–52.4	34	46.7 ± 7.2	32.9–61.1
Textile, apparel, and furnishings machine operators	205,498	2[a]	14.1 ± 10.7	2.7–49.3	5[a]	30.0 ± 16.3	8.2–67.2	8[a]	56.0 ± 17.6	23.2–84.3
Machine operators, assorted materials	1,190,439	15[a]	12.2 ± 4.6	5.6–24.7	36	39.8 ± 6.5	27.6–53.4	42	48.0 ± 5.6	37.0–59.1
Fabricators, assemblers, inspectors, and samplers	1,008,093	16[a]	25.0 ± 6.6	14.1–40.5	22[a]	33.7 ± 8.4	19.2–52.0	35	41.3 ± 7.5	27.4–56.8
Motor vehicle operators	1,689,775	28[a]	18.8 ± 4.0	12.0–28.2	27[a]	22.9 ± 3.7	16.3–31.1	52	58.3 ± 5.0	47.9–68.0
Other transportation and material moving occupations	616,014	9[a]	18.2 ± 4.0	11.5–27.8	13[a]	35.7 ± 8.4	21.0–53.7	16[a]	46.0 ± 8.0	30.9–62.0
Construction laborers	362,272	4[a]	8.5 ± 5.0	2.5–25.6	14[a]	31.7 ± 8.5	17.4–50.7	23[a]	59.8 ± 8.3	42.5–74.9
Laborers, except construction	323,064	2[a]	8.6 ± 6.1	1.9–31.2	10[a]	52.0 ± 11.4	30.2–73.1	11[a]	39.4 ± 11.2	20.1–62.7
Freight, stock, and material movers, hand	730,436	17[a]	16.6 ± 5.5	8.2–30.5	29[a]	39.7 ± 7.7	25.6–55.7	28[a]	43.8 ± 7.5	29.6–59.0
Other helpers, equipment cleaners, hand packagers, and laborers	662,024	11[a]	23.8 ± 7.6	11.8–42.2	28[a]	38.2 ± 7.0	25.4–53.0	26[a]	37.9 ± 6.6	25.7–51.9

[a]Estimates do not meet the National Center for Health Statistics standard of reliability or precision because the sample size is <30 and/or the sample size is <30 and has a relative standard error ≥ 30%. A significantly ($P < 0.05$) *lower or **higher prevalence of low cardiovascular fitness for an occupation category compared with all other occupations combined is denoted by age- and sex-adjusted logistic regressions. [b]Our estimated population of US workers is lower due to the number of NHANES participants who completed the VO_2max test.

blue-collar occupations (16% to 55%). Thus, the current findings of high prevalence of low CVF in some blue collar occupations are not surprising, given the modest relationship between physical activity and CVF.

Utilizing the 1999 to 2004 NHANES, this group found that 20% of all workers met criteria for cardiometabolic syndrome, with miscellaneous food preparation and food service workers and farm operators, managers, and supervisors having the highest prevalence (30%).[29] These results are consistent with the current study, given that 16% of all workers had a low level of CVF, and miscellaneous food preparation and food service workers and farm operators, managers, and supervisors had a particularly high prevalence of low CVF. Several cross-sectional and longitudinal studies show that CVF is inversely associated with cardiometabolic syndrome.[33–36]

Because we used a nationally representative sample of adults in the United States population, the results of this study provide useful information for decision makers and employers who are conducting and/or planning wellness programs, specifically with the goal of improving CVF. Focusing on improving CVF will not only result in a healthier labor force by preventing many people from developing chronic disease, but also can work to reverse disease symptoms for those already diagnosed.[13,14,33] In addition, investing in the fitness and general health of employees saves money in terms of enhanced productivity and lower health care costs.[37,38]

The primary limitation of this study is the inability to ascertain causality, given its cross-sectional nature. It cannot be determined if simply working as a farm operator, secretary, or a retail sales worker contributes to low levels of CVF because of the lack of physical demands on the job and/or if people choosing these types of occupations do not typically engage in enough exercise to demonstrate higher levels of CVF at the time of the assessment.[28] Likewise, it is unknown if scientists, health-related occupations, teachers, or construction laborers have a greater prevalence of high CVF because their positions are more physically oriented (eg, health technicians spend a good deal of time on their feet) or if these positions afford these workers the time and/or access to exercise compared with other occupation groups (eg, teachers have access to the school gymnasium). Nonetheless, others have found that workers with job-characterizing demands (including shift work and physical strain) are more sedentary than workers who are more autonomous.[39] Blue collar workers report low levels of physical activity,[28] which do not directly relate to the amount of time spent working.[40] In addition, blue collar occupations may be more difficult to target for physical activity intervention due to intraindividual, interpersonal, and bureaucratic norms.[41–43] For example, a farm operator may work alone in an isolated rural location that lacks access to convenient exercise facilities. Secretaries may not feel empowered to leave their work place during the day to exercise without an environment that fosters health and wellness.

Given the beneficial effect that CVF, possibly independent of obesity,[30,44,45] has on reducing the risk of CAD/CVD, diabetes, cardiometabolic syndrome, and all-cause mortality,[46–50] employer awareness of this population-based assessment by occupation is of paramount importance to foster improved worksite wellness and health promotion activities.[3] Increasing CVF, and the expected concomitant weight loss, may also augment the quantity of work performed, reduce the amount of extra effort required to perform the job, and improve indicators of presenteeism; although, this area of investigation has been relatively unstudied.[51] In addition, obese workers have been shown to be at greater risk for worksite traumatic injuries,[52] hence improved CVF could indirectly counter this problem as well. Having a moderate–to-high level of CVF, while it may not directly translate into lower levels of absenteeism, would reduce the incidence and prevalence of many chronic diseases, and therefore any worksite wellness program should contain elements focused on improving CVF levels related to the known health benefits.[53] In addition, modifiable risk factors, such as depression, hyperglycemia, obesity, hypertension, and a sedentary lifestyle, are related to higher employer health care expenditures,[54] and these factors are directly counteracted by improving CVF levels. Therefore, continued efforts at increasing the levels of CVF in the American workforce are critically important to curtail the effects of the various epidemics of chronic disease in the United States.

In summary, these data suggest that levels of CVF are varied among the United States working population. Some occupation categories require strategies to improve CVF levels more than others, while taking into account the type of job and the demands and constraints related to the organization. Additional studies that look at the combined effects of CVF, measures of body composition, and increasingly prevalent morbid conditions, including cardiometabolic syndrome, may provide employers with better approaches to reduce the risk of CAD/CVD, diabetes, and other related complications that are known to be counteracted by increasing CVF. Future work can examine whether longitudinal changes in CVF mediate the risk of these diseases within occupation groups.

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