Economic Impact of Moderate-Vigorous Physical Activity Among Those With and Without Established Cardiovascular Disease: 2012 Medical Expenditure Panel Survey

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Background—Physical activity (PA) has an established favorable impact on cardiovascular disease (CVD) outcomes and quality of life. In this study, we aimed to estimate the economic effect of moderate-vigorous PA on medical expenditures and utilization from a nationally representative cohort with and without CVD.

Methods and Results—The 2012 Medical Expenditure Panel Survey data were analyzed. Our study population was limited to noninstitutionalized US adults ≥18 years of age. Variables of interest included CVD (coronary artery disease, stroke, heart failure, dysrhythmias, or peripheral artery disease) and cardiovascular modifiable risk factors (CRFs; hypertension, diabetes mellitus, hypercholesterolemia, smoking, and/or obesity). Two-part econometric models were utilized to study cost data; a generalized linear model with gamma distribution and link log was used to assess expenditures per capita. The final study sample included 26 239 surveyed individuals. Overall, 47% engaged in moderate-vigorous PA ≥30 minutes, ≥5 days/week, translating to 111.5 million adults in the United States stratifying by CVD status; 32% reported moderate-vigorous PA among those with CVD versus 49% without CVD. Generally, participants reporting moderate-vigorous PA incurred significantly lower health care expenditures and resource utilization, displaying a step-wise lower total annual health care expenditure as moving from CVD to non-CVD (and each CRF category).

Conclusions—Moderate-vigorous PA ≥30 minutes, ≥5 days/week is associated with significantly lower health care spending and resource utilization among individuals with and without established CVD. **(*J Am Heart Assoc*. 2016;5: e003614 doi: 10.1161/JAHA.116.003614)**

Key Words: cardiovascular disease • cost • exercise • risk factors

Cardiovascular disease (CVD) continues to be the leading cause of mortality and disability world-wide.[1] One of the most important cardiovascular modifiable risk factors (CRFs) is lack of physical activity (PA), including prominently the lack of intentional moderate-vigorous PA. It has been documented that 150 minutes per week of moderate-vigorous physical activity is sufficient to observe a reduction in all-cause mortality risks,[2,3] aside from also aiding in morbidity,[4] and overall decrease in CVD risk.[5] In spite of the benefits of PA, and its widely reported positive impact on most CRFs,[4,6] its

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prevalence is well below desired levels, despite numerous interventions to increase PA.[7–11] In addition, many previous studies have sought to describe the economic impact of PA on health status,[12–22] but these either exclusively studied older populations and/or evaluated health-related charges (rather than expenditures). In addition, no nation-wide economic impact of PA has been reported in recent years.

In this study, we aimed to describe the impact of moderate-vigorous PA on health care expenditure and resource utilization across the spectrum of CVD status and CRF profiles from a sample generalizable to the entire US population, and hypothesized that health care expenditures and utilization were lower among individuals who engaged in moderate-vigorous PA.

Methods

Study Design and Sampling

This retrospective study used data from the Medical Expenditure Panel Survey (MEPS), 2012. The MEPS, led by the Agency for Healthcare Research and Quality, is a set of large-scale, national surveys about individuals and families and their medical providers and employers. The Household Component (HC) of the MEPS collects data about health services used, their frequency and cost, charges, source of payment, income, employment, as well as ample data on insurance used by and available to US workers.[23] The MEPS respondents are enrolled for 2 years of data collection, with a new panel beginning each year. The sampling frame for the MEPS-HC is drawn from respondents to the National Health Interview Survey, and the design of the MEPS-HC survey includes sampling weights, stratification, and clustering. The MEPS sampling weights incorporate adjustment for the complex sample design and reflect survey nonresponse and population totals from the Current Population Survey.[23]

Of all files in the HC of the survey, we used the full-year consolidated data files and medical conditions files. The full-year consolidated data files contain most demographics at a person level, including information on resource utilization and costs, whereas the medical conditions files include each diagnosis a person has, which, after being transcribed verbatim at each survey, are translated into International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM) by professional coders. These files were linked together in order to determine accurate results for each individual. Because MEPS is comprised of publicly available, de-identified data files, this study was exempt of institutional review board approval.[24]

Participants

The initial sample consisted of 38 974 surveyed individuals. We limited our study population to noninstitutionalized US adults ≥18 years of age (excluding 11 154 individuals <18 years of age). Individuals with body mass index (BMI) <18.5 kg/m^2 (532) were further excluded from the sample given that they often represent a sicker patient population. Because of the subject matter of this study, individuals who, for the entire survey period, were either completely unable to walk or unable to walk up 10 steps (130) or pregnant at any point during the survey (919) were also excluded from all analyses.

Study Variables

Physical activity

Individuals in the study sample were classified into PA based on their answers to the question, "Do you currently spend half hour or more in moderate to vigorous physical activity, at least five times a week?" The 2010 MEPS glossary (valid for all subsequent surveys) states, "moderate physical activity causes only light sweating or a slight or moderate increase in breathing or heart rate and would include activities such as fast walking, raking leaves, mowing the lawn, or heavy cleaning. Vigorous physical activity causes heavy sweating or large increases in breathing or heart rate and would include activities such as running, race walking, lap swimming, aerobic classes, or fast bicycling."[25] Participants who answered "yes" to this question were categorized as "optimal PA," and "nonoptimal PA" otherwise. An important point to be made is that most respondents who engaged in this level of PA closely resemble what most researchers refer to as "exercise." Consequently, our categorization of nonoptimal PA individuals does not necessarily mean "sedentary," but that the 2008 Physical Activity Guidelines Advisory Committee Report recommendations for PA were not met.[4]

Cardiovascular disease and average cardiovascular modifiable risk factor profile

Individuals in the study sample that had a diagnosis of coronary artery disease, stroke, heart failure, dysrhythmias, and/or peripheral artery disease (ascertained by ICD-9-CM codes: 410, 413, 414, 433–437, 427, 428, 440, 443, and 447, respectively) were classified as having diagnosed CVD. CRFs were ascertained using self-reported questionnaires in the MEPS-HC survey, where individuals with presence of 1 or more of: hypertension, diabetes mellitus, hypercholesterolemia, smoking, and/or obesity (BMI ≥30 kg/m^2, a constructed variable using self-reported weight and height) were included. Based on the presence of these individual risk factors, survey participants were profiled as "poor" (≥3 cardiovascular risk factors), "average" (2 cardiovascular risk factors), or "optimal" (0–1 cardiovascular risk factors).

Expenditures and resource utilization

Total annual direct medical expenditures were calculated for each person. Data for the calculation of this variable included expenditures from all payer groups and out-of-pocket spending, including information from hospitalizations, prescribed medications, outpatient visits (hospital outpatient visits and office-based visits), emergency department (ED) visits, and other expenditures (dental visits, vision aid, home health care, and other medical supplies). In a similar fashion, resource utilization analysis assessed the total number of outpatient and ED visits, number of hospitalizations, and number of prescription medications' purchases/refills each surveyed individual incurred.

Covariates

Other variables included in the study were age, sex, health status, family income, race/ethnicity, employment, metropolitan statistical area, insurance type, education, geographical region, and modified Charlson Comorbidity Index (without cardiovascular components). Categorical variables were classified as follows: 5 categories were used for age (18–39, 40–54, 55–64, 65–74, and ≥75); 3 categories for family income (poor/near poor [<125% of the 2012 federal poverty level], low/middle income [125% to <400% federal poverty level], and high income [≥400% federal poverty level]); 5 categories for race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic Asian, non-Hispanic other, and Hispanic); 3 categories for insurance type (private, public only, and uninsured); 5 categories for education (less than high school, high school diploma, some college, college [bachelor's degree] and masters, doctorate, or professional); 4 categories for geographical region (Northeast, Midwest, South, and West); and 3 categories for modified Charlson Comorbidity Index (0, 1, and ≥2).

Statistical Analysis

For comparison of demographic characteristics in our sample, chi-square tests were performed.[26] Because of the right-skewedness of expenditures data (ie, most expenditures are seen in only a small proportion of the population), two-part models were utilized to study expenditures.[27] Two-part models are often used to model health care expenditures, and are the product of: (1) the probability that any given individual had any expenditures and (2) their mean expenditures.[28] The first part of the model consists on a probabilistic regression model (*probit*), which estimates the probability of zero versus positive expenditures. Contingent upon having a positive annual health care expenditure, a generalized linear model (*glm*) with gamma distribution and a logarithmic-link function estimates the average expenditure per capita[28,29]; we determined the distribution of the *glm* using the modified Park Test.[30] For resource utilization, unadjusted and adjusted logistic regression models were utilized. Unadjusted means and proportions were calculated, adjusting for the survey design and sampling weight. For multivariate analyses, variable selection for inclusion into the model was determined using a combination of the Akaike information criterion and their relevance toward cost analysis. Collinearity was assessed using the variance inflated factor. For all statistical analyses, $P<0.05$ was considered statistically significant. All analyses were carried out using Stata software (version 13.1; StataCorp LP, College Station, TX). Total and marginal expenditures were estimated using the "margins" command after the two-part models.[28] All analyses took into consideration the MEPS complex survey design.

Results

Population Characteristics

The final study population consisted of 26 239 participants ≥18 years of age (47.6±17 years; 51.5% female), which translates to ≈223.7 million US adults; demographic information is presented in Table 1. Overall, 1896 (9%) had a CVD diagnosis, representing 19.4 million of the noninstitutionalized adult population in the United States. Forty-nine percent of those without CVD and 32% of those with CVD reported engaging in moderate-vigorous PA. Irrespective of CVD status, participants with optimal PA were less likely to have underlying CVD risk factors, as well as reporting better health status, higher socioeconomic and education strata, and lower prevalence of comorbid conditions (Table 1).

Healthcare Expenditures

Univariate and multivariate models estimating average per capita health care expenditures are presented in Table 2. Presence of CVD was independently associated with higher health care expenditures when compared to individuals without CVD. Despite this, presence of optimal PA was associated with lower health care expenditures across CVD status and CRF spectrum. Among those without CVD, those with optimal CRF and PA had a mean annual expenditure of \$2328 (95% CI, 1932, 2726), compared to \$5475 (95% CI, 4668, 6283) of those with poor CRF and PA (Table 2, model 1). After adjusting for other covariates (demographics, socioeconomic status, insurance type, and comorbidities), these marked differences remained (Table 2, model 3). Moreover, when comparing the marginal expenditures of optimal PA versus nonoptimal PA, the impact of PA on health

Table 1. Sample Characteristics from the Medical Expenditure Panel Survey 2012, Stratified by Physical Activity and CVD Status

	CVD			Non-CVD		
	Nonoptimal PA	Optimal PA	*P* Value	Nonoptimal PA	Optimal PA	*P* Value
Sample, n	1293	603		12 510	11 833	
Weighted sample	12 539 605	6 822 007		99 586 391	104 714 281	
Age strata, y, n (%)			<0.001			<0.001
18–39	54 (4.2)	36 (6.0)		5016 (40.1)	5642 (47.7)	
40–54	184 (14.2)	101 (16.7)		3720 (29.7)	3304 (27.9)	
55–64	289 (22.4)	146 (24.2)		1993 (15.9)	1671 (14.1)	
65–74	334 (25.8)	185 (30.7)		1094 (8.7)	844 (7.1)	
≥75	432 (33.4)	135 (22.4)		687 (5.5)	372 (3.1)	
Sex, n (%)			<0.001			<0.001
Female	656 (50.7)	248 (41.1)		7127 (57.0)	5479 (46.3)	
Male	637 (49.3)	355 (58.9)		5383 (43.0)	6354 (53.7)	
Hypertension, n (%)			<0.001			<0.001
No	240 (18.6)	161 (26.7)		8425 (67.3)	8952 (75.7)	
Yes	1053 (81.4)	442 (73.3)		4085 (32.7)	2881 (24.3)	
Diabetes mellitus, n (%)			<0.001			<0.001
No	855 (66.1)	446 (74.0)		11 243 (89.9)	11 079 (93.6)	
Yes	438 (33.9)	157 (26.0)		1267 (10.1)	754 (6.4)	
Hypercholesterolemia, n (%)			0.02			<0.001
No	362 (28.0)	200 (33.2)		9039 (72.3)	9314 (78.7)	
Yes	931 (72.0)	403 (66.8)		3471 (27.7)	2519 (21.3)	
Current smoker, n (%)			0.12			0.11
No	1074 (83.1)	518 (85.9)		10 611 (84.8)	9949 (84.1)	
Yes	219 (16.9)	85 (14.1)		1899 (15.2)	1884 (15.9)	
Obese, n (%)			<0.001			<0.001
No	715 (55.3)	399 (66.2)		8142 (65.1)	8951 (75.6)	
Yes	578 (44.7)	204 (33.8)		4368 (34.9)	2882 (24.4)	
CRF profile*, n (%)			<0.001			<0.001
Optimal	263 (20.3)	182 (30.2)		8164 (65.3)	8913 (75.3)	
Average	366 (28.3)	181 (30.0)		2414 (19.3)	1823 (15.4)	
Poor	664 (51.4)	240 (39.8)		1932 (15.4)	1097 (9.3)	
Health status, n (%)			<0.001			<0.001
Excellent	44 (3.4)	44 (7.3)		2059 (16.5)	3134 (26.5)	
Very good	198 (15.3)	190 (31.5)		4603 (36.8)	5186 (43.8)	
Good	470 (36.3)	239 (39.6)		4068 (32.5)	2786 (23.5)	
Fair	422 (32.6)	111 (18.4)		1436 (11.5)	630 (5.3)	
Poor	159 (12.3)	19 (3.2)		268 (2.1)	61 (0.5)	
Family income, n (%)			<0.001			<0.001
Poor/near poor	417 (32.3)	133 (22.1)		3291 (26.3)	2585 (21.8)	
Low/middle income	579 (44.8)	264 (43.8)		5898 (47.1)	5525 (46.7)	
High income	297 (23.0)	206 (34.2)		3321 (26.5)	3723 (31.5)	

Continued

Table 1. Continued

	CVD			Non-CVD		
	Nonoptimal PA	Optimal PA	*P* Value	Nonoptimal PA	Optimal PA	*P* Value
Race/ethnicity, n (%)			0.06			<0.001
Non-Hispanic White	748 (57.8)	375 (62.2)		4732 (37.8)	5060 (42.8)	
Non-Hispanic Black	276 (21.3)	105 (17.4)		2570 (20.5)	2357 (19.9)	
Non-Hispanic Asian	45 (3.5)	31 (5.1)		1031 (8.2)	857 (7.2)	
Non-Hispanic Other	24 (1.9)	13 (2.2)		265 (2.1)	273 (2.3)	
Hispanic	200 (15.5)	79 (13.1)		3912 (31.3)	3286 (27.8)	
Metropolitan area, n (%)			0.25			0.97
No	227 (17.6)	93 (15.4)		1424 (11.4)	1345 (11.4)	
Yes	1066 (82.4)	510 (84.6)		11 086 (88.6)	10 488 (88.6)	
Insurance status, n (%)			<0.001			<0.001
Private	582 (45.0)	359 (59.5)		6608 (52.8)	7046 (59.5)	
Public only	641 (49.6)	204 (33.8)		2737 (21.9)	1908 (16.1)	
Uninsured	70 (5.4)	40 (6.6)		3165 (25.3)	2879 (24.3)	
Education, n (%)			<0.001			<0.001
Less than high school	356 (27.5)	107 (17.7)		2958 (23.6)	2197 (18.6)	
GED or high school diploma	428 (33.1)	202 (33.5)		3645 (29.1)	3502 (29.6)	
Some college	281 (21.7)	124 (20.6)		3025 (24.2)	3246 (27.4)	
College (bachelor's degree)	139 (10.8)	103 (17.1)		1734 (13.9)	1813 (15.3)	
Masters, doctorate or professional	74 (5.7)	65 (10.8)		891 (7.1)	956 (8.1)	
Region, n (%)			0.75			<0.001
Northeast	233 (18.0)	118 (19.6)		2084 (16.7)	1860 (15.7)	
Midwest	282 (21.8)	133 (22.1)		2200 (17.6)	2232 (18.9)	
South	537 (41.5)	250 (41.5)		4820 (38.5)	4295 (36.3)	
West	241 (18.6)	102 (16.9)		3406 (27.2)	3446 (29.1)	
Modified Charlson Comorbidity Index†, n (%)			<0.001			<0.001
0	842 (65.1)	454 (75.3)		11 009 (88.0)	10 791 (91.2)	
1	275 (21.3)	93 (15.4)		1053 (8.4)	744 (6.3)	
≥2	176 (13.6)	56 (9.3)		448 (3.6)	298 (2.5)	

CRF indicates cardiovascular risk factor; CVD, cardiovascular disease; GED, general education development; PA, physical activity.
*Cardiovascular risk factors: hypertension, diabetes mellitus, hypercholesterolemia, obesity, and smoking.
†Charlson Comorbidity Index without cardiovascular components.

care expenditures was highest for those with established CVD, followed by participants without CVD but underlying poor CRF profile (Table 2).

Weighted and adjusted estimates by specific expenditure category (health care utilization expenditures: hospitalizations, prescription medications, ED visits, outpatient visits, and other) according to CRF profile and CVD status are presented in Figure 1. Among those with CVD, the highest expenditures pertained to hospitalizations (with expenditures of $5644 and $4233 for nonoptimal PA and optimal PA, respectively), followed by prescription medications and outpatient visits. Among those without CVD, the major part of costs among non-CVD individuals was attributed to outpatient visits, with those with poor CRF spending an annual average of $2019 and $1918 (nonoptimal PA and optimal PA, respectively), compared to $1319 and $1215 of those with optimal CRF. The highest differences were noted in prescription medications, with those with a poor CRF profile and nonoptimal PA spending $400 more than their optimal PA counterparts. The lowest expenditures were noted among those without CVD, with optimal CRF profile and optimal PA, with an average of $810 on hospitalizations, $587 on prescription medications, and $1215 on outpatient visits (Figure 1).

Table 2. Average Expenditures of Physical Activity Per Capita, by CVD Status and CRF Category

	Total		CVD		Non-CVD					
					Cardiovascular Risk Factor Profile					
					Poor		Average		Optimal	
	Expenditure	95% CI	Expenditure	95% CI	Expenditure	95% CI	Expenditure	95% CI	Expenditure	95% CI
Model 1										
Nonoptimal PA	$5397.61	(5064, 5731)	$14 569.82	(13 209, 15 931)	$7567.77	(6700, 8436)	$5191.04	(4568, 5814)	$3053.79	(2713, 3394)
Optimal PA	$3443.45	(3111, 3776)	$10 586.93	(8508, 12 666)	$5475.72	(4668, 6283)	$4476.12	(3709, 5243)	$2328.69	(1932, 2726)
Model 2										
Nonoptimal PA	$5012.54	(4691, 5334)	$14 564.70	(11 057, 18 072)	$6636.04	(5755, 7517)	$4542.76	(4000, 5086)	$3496.36	(3048, 3945)
Optimal PA	$3787.56	(3451, 4124)	$10 743.88	(7347, 14 140)	$5173.92	(4413, 5935)	$4003.99	(3380, 4628)	$2847.15	(2374, 3320)
Model 3										
Nonoptimal PA	$4867.82	(4552, 5183)	$12 659.57	(8992, 16 327)	$6339.80	(5515, 7164)	$4577.91	(4044, 5112)	$3733.97	(3258, 4210)
Optimal PA	$4153.53	(3821, 4486)	$10 092.42	(6556, 13 629)	$5279.12	(4477, 6081)	$4147.37	(3552, 4743)	$3240.39	(2765, 3716)

Cardiovascular risk factors: hypertension, diabetes mellitus, hypercholesterolemia, obesity, and smoking. Model 1: unadjusted. Model 2: adjusted for age, sex, family income, and race/ethnicity. Model 3: adjusted for variables in model 2 plus insurance type, geographical region, and modified Charlson Comorbidity Index (Charlson Comorbidity Index without cardiovascular components). CRF indicates cardiovascular risk factor; CVD, cardiovascular disease; PA, physical activity.

Healthcare Resource Utilization

Table 3 summarizes health care utilization rates across PA, CRF, and CVD categories. Overall, optimal PA was associated with significantly less use of health care resources. Among surveyed participants with CVD, those with optimal versus nonoptimal PA were less likely to have an ED visit (24% vs 31%) or any hospitalization (21% vs 27%). The lowest rate of ED visits (9.1%) and hospitalizations (2.6%) was noted among those reporting optimal PA without a CVD diagnosis and presence of optimal CRF profile. After adjusting for key covariates, among individuals without CVD, those with optimal PA had lower odds of being hospitalized (optimal CRF: odds ratio [OR], 0.75; 95% CI [0.60, 0.93]; average CRF: OR, 0.70; 95% CI [0.51, 0.95]; poor CRF: OR, 0.65; 95% CI [0.45, 0.93]), lower odds of having an outpatient visit (optimal CRF: OR, 0.88; 95% CI [0.80, 0.97], average CRF: OR, 0.67; 95% CI [0.55, 0.82], poor CRF: OR, 0.69; 95% CI [0.51, 0.94]), and lower odds of purchasing/refilling a prescription medication (optimal CRF: OR, 0.83; 95% CI [0.75, 0.92], average CRF: OR, 0.73; 95% CI [0.60, 0.89], poor CRF: OR, 0.65; 95% CI [0.48, 0.88]). Similar trends were noted for "high health care utilizers" (at or above the 75th percentile for usage at each particular healthcare resource; Figure 2A and 2B).

Discussion

Past reports have described the relationship between some level of PA and costs[13,17,19,20,22,31]; however, none have recently shown this on the basis of CVD,[16] with a focus on CRFs. This study provides current estimates from a nationally representative sample of the US population. We found lower health care expenditures and resource utilization associated with moderate-vigorous PA, regardless of CVD status. Additionally, we found significantly lower health care expenditures of PA individuals by each individual CRF profile.

Our results are consistent with most past reports and are an important addition to the understanding of health care expenditures relating to PA. First, this study adds to current literature by providing current national estimates of health care savings among those who engage in moderate-vigorous PA. Second, this project not only ascertains the differences between CVD and non-CVD populations, but also brings a special focus on non-CVD individuals and their CRF profile to demonstrate that efforts concerning prevention are still much needed. Third, to the authors' knowledge, this is the first attempt to describe both costs and their relating resource utilization estimates regarding PA in a single study.

It has become widely accepted that PA leads to better health outcomes and enhances the prevention of diseases like CVD, diabetes mellitus, cancer, hypertension, obesity, depression, and osteoporosis.[32] Consequently, many studies have

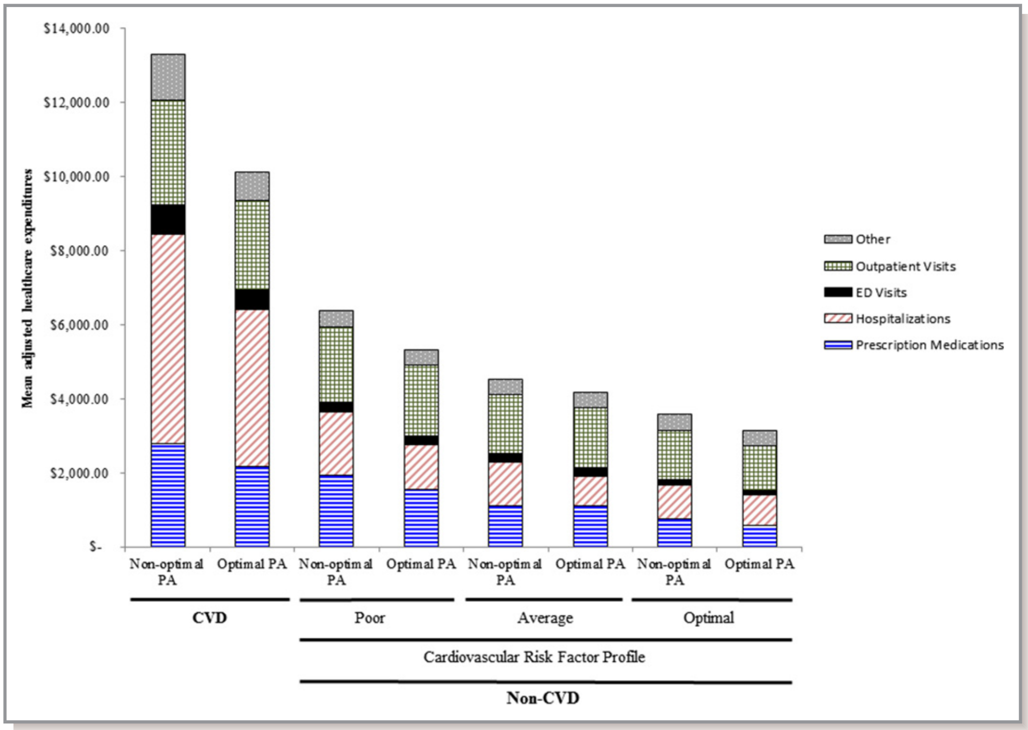

Figure 1. Weighted, adjusted mean health care expenditures by category, among optimal and nonoptimal PA, with and without CVD, further subclassified by CRF profile. CRF indicates cardiovascular risk factor; CVD, cardiovascular disease; ED, emergency department. Other=dental, vision aid, home healthcare, medical devices, others; PA, physical activity. Cardiovascular risk factors: hypertension, diabetes mellitus, hypercholesterolemia, obesity, and smoking. Non-CVD: adjusted for age, sex, family income, race/ethnicity, insurance type, geographical region, and modified Charlson Comorbidity Index (without cardiovascular components). CVD: adjusted for "non-CVD" covariates plus cardiovascular risk factors.

assessed PA's economic impact. Some have reported no differences in savings related to PA; Chevan et al. found no short-term savings related to PA,[13] whereas Martinson et al. found no differences for those in their forties, but significant lower short-term charges in those physically active aged 50 and above, compared to those inactive.[15] Others have found the opposite to be true. Wang et al. reported savings of more than 50% when comparing CVD versus non-CVD individuals from a nationally representative sample.[16] From our results, we estimate that PA results in a 20% reduction in health care expenditure among those with CVD and in a 50% reduction when comparing those with CVD versus non-CVD and having poor CRF (the most affected individuals in the non-CVD categorization; Table 2, model 3). Similarly, Pronk et al. studied modifiable health risks and short-term health care–related charges, and found that those that engaged in PA had a 4.7% reduction in median charges when compared to those not engaged in PA. Additionally, they reported that in a general population of ≥60 years of age, without diabetes mellitus, or congenital heart disease, high-risk individuals (BMI ≥25 kg/m^2, current smokers, and no PA) had a consistent 49% increase in mean annual charges compared to low-risk individuals.[14] Likewise, even with a slightly different classification of risk factors, our results show health care savings of more than 50% when comparing poor versus optimal CRF, regardless of PA (Table 2, model 3). Furthermore, our results show relative savings of 16.7% and 13% when comparing optimal PA versus nonoptimal PA among those with poor and optimal CRF, respectively. More recently, Carlson et al. reported that inactive adults spent $920 more than their active equivalents.[12] Although Carlson et al. did not focus on CVD, our results seem to be in line with their findings, with −$723 as the difference between optimal PA versus nonoptimal PA in the multivariate model, in the general population. Another recent study analyzed costs related to PA using the Cooper Center Longitudinal Study (CCLS).[17] They found that expenditures in later life (≥65 years of age) were greatly diminished if cardiorespiratory fitness was achieved in midlife years (around 50 years of age). Our results are not readily comparable with theirs given that they only studied Medicare- and Medicaid-covered individuals. Moreover, individuals from the CCLS tend to be healthier than the general US population.[33] Notwithstanding, their conclusions and ours support the same concept: PA needs to be promoted and/or improved, with data to bolster third-party payers into action for a less-devastating economic future for the nation,

Table 3. Health Care Resource Utilization Physical Activity Categories, by CVD Status and CRF Category

	CVD		Non-CVD					
			Cardiovascular Risk Factor Profile					
			Poor		Average		Optimal	
	Optimal PA	Nonoptimal PA	Optimal PA	Nonoptimal PA	Optimal PA	Nonoptimal PA	Optimal PA	Nonoptimal PA
Health care utilization								
Hospitalizations								
Proportion with any hospitalizations, %	21.0	27.2	7.9	11.8%	5.7	8.0	2.6	3.4
Average hospitalizations among those with ≥1 hospitalization	1.26	1.44	1.19	1.34	1.23	1.28	1.24	1.21
ED visits								
Proportion with any visit	24.1	30.9	15.3	18.8	12.5	15.8	9.1	9.2
Average visits among those with ≥1 visit	1.47	1.61	1.31	1.44	1.38	1.45	1.31	1.31
Outpatient visits								
Proportion with any visit, %	94.7	95.6	85.0	89.1	74.1	81.0	60.5	63.5
Average visits among those with ≥1 visit	11.55	14.94	8.22	9.99	7.96	8.55	5.88	6.81
Prescription medications								
Proportion with ≥1 purchase/refill, %	97.2	97.3	87.7	91.7	76.6	81.7	48.9	53.5
Average purchases/refills among those with ≥1 purchase/refill	31.93	45.96	24.92	33.45	16.53	19.44	8.71	11.95
High (≥75th percentile) health care utilization								
Hospitalizations								
Proportion ≥75th percentile, %	21.0	27.2	7.9	11.8	5.7	8.0	2.6	3.4
Average hospitalizations among those ≥75th percentile	1.26	1.44	1.19	1.34	1.23	1.28	1.24	1.21
ED visits								
Proportion ≥75th percentile, %	7.0	10.9	3.3	5.1	3.0	4.4	1.9	1.9
Average visits among those ≥75th percentile	2.61	2.73	2.46	2.64	2.58	2.6	2.5	2.5
Outpatient visits								
Proportion ≥75th percentile, %	48.1	56.6	25.9	35.9	23.2	26.9	12.4	16.2
Average visits among those ≥75th percentile	18.82	22.59	19.66	19.53	18.36	19.34	18.57	18.77
Prescription medications								
Proportion ≥75th percentile, %	48.2	64.5	32.8	45.1	15.9	22.8	3.6	7.2
Average visits among those ≥75th percentile	50.67	62.34	48.09	56.25	44.46	45.12	37.61	44.11

Cardiovascular risk factors: hypertension, diabetes mellitus, hypercholesterolemia, obesity, and smoking. CRF indicates cardiovascular risk factor; CVD, cardiovascular disease; ED, emergency department; PA, physical activity.

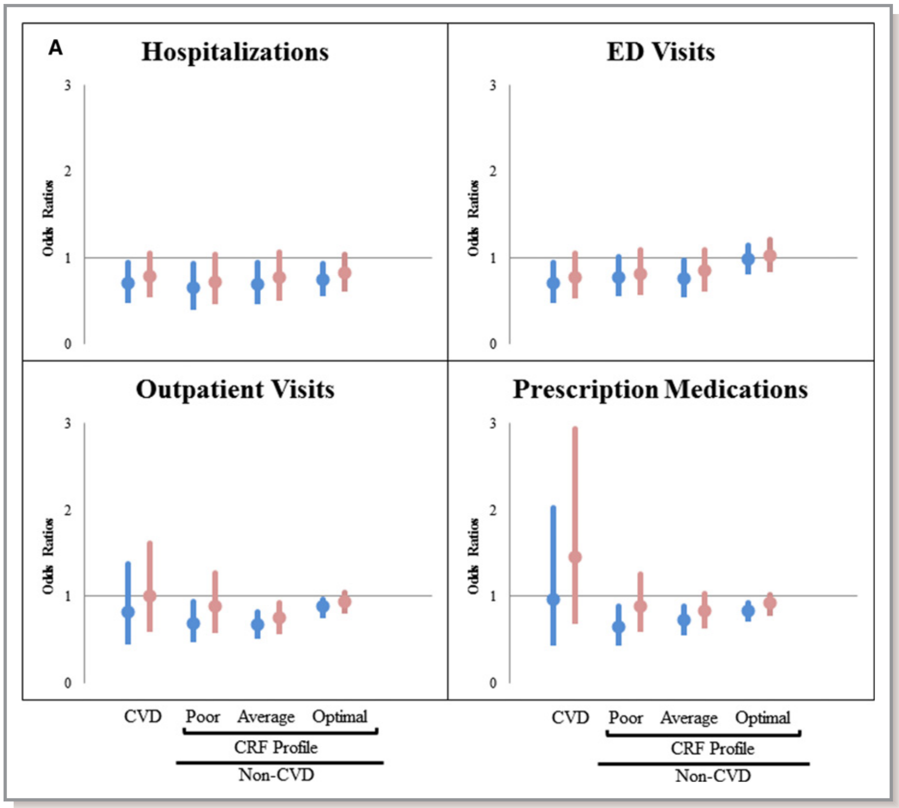

Figure 2. A, Odds ratios for health care utilization of optimal PA versus nonoptimal PA. CRF indicates cardiovascular risk factor profile; ED, emergency department; PA, physical activity. Color scheme: blue bars, univariate model; red bars; multivariate model. Cardiovascular risk factors: hypertension, diabetes mellitus, hypercholesterolemia, obesity, and smoking. Non-CVD: adjusted for age, sex, family income, race/ethnicity, insurance type, geographical region, and modified Charlson Comorbidity Index (without cardiovascular components). CVD: adjusted for "non-CVD" covariates plus cardiovascular risk factors. B, Odds ratios for "high" (≥75% percentile) healthcare utilization of optimal PA versus nonoptimal PA. CRF indicates cardiovascular risk factor; ED, emergency department. Color scheme: blue bars, univariate model; red bars, multivariate model. Cardiovascular risk factors: hypertension, diabetes mellitus, hypercholesterolemia, obesity, and smoking. Non-CVD: adjusted for age, sex, family income, race/ethnicity, insurance type, geographical region, and modified Charlson Comorbidity Index (without cardiovascular components). CVD: adjusted for "non-CVD" covariates plus cardiovascular risk factors. *Note*: "High hospitalizations" equaled 1 hospitalization, given the right shift of utilization.

especially given that chronic disease prevalence is on the rise.[34,35] From the health care resource utilization point of view, a Canadian study reported an inverse association with PA and utilization among individuals 65 years and older.[36] Our results too show a tendency of diminishing resource utilization when comparing optimal PA versus nonoptimal PA, especially when comparing CVD and non-CVD individuals.

Overwhelming evidence points toward a world-wide increase in prevalence of noncommunicable chronic diseases. Dall et al. estimated that by the year 2025, most growth in outpatient visits will be reflected primarily in the field of cardiology, which, along with vascular surgery, will have the highest projected growth in demand.[37] Consequently, several initiatives have been set up with a goal to help mitigate the increase in noncommunicable diseases, such as the American Heart Association's (AHA) 2020 Strategic Goals,[34] Health 2020,[38] or the "25×25" Strategy.[39] Unsurprisingly, PA is an integral part of all these efforts, and yet the current prevalence of PA engagement remains below 50% for non-CVD and below 35% for CVD individuals, according to our results, including the advent of recent reports favoring interventions among middle-aged individuals,[40] or even identifying the benefits of simpler strategies, such as walking, in the prevention of CVD.[41]

Several limitations of this study should be noted. First, because of the limited assessment of PA degree in the MEPS questionnaires, we were only able to dichotomize PA levels as those engaging versus not in self-reported moderate-vigorous

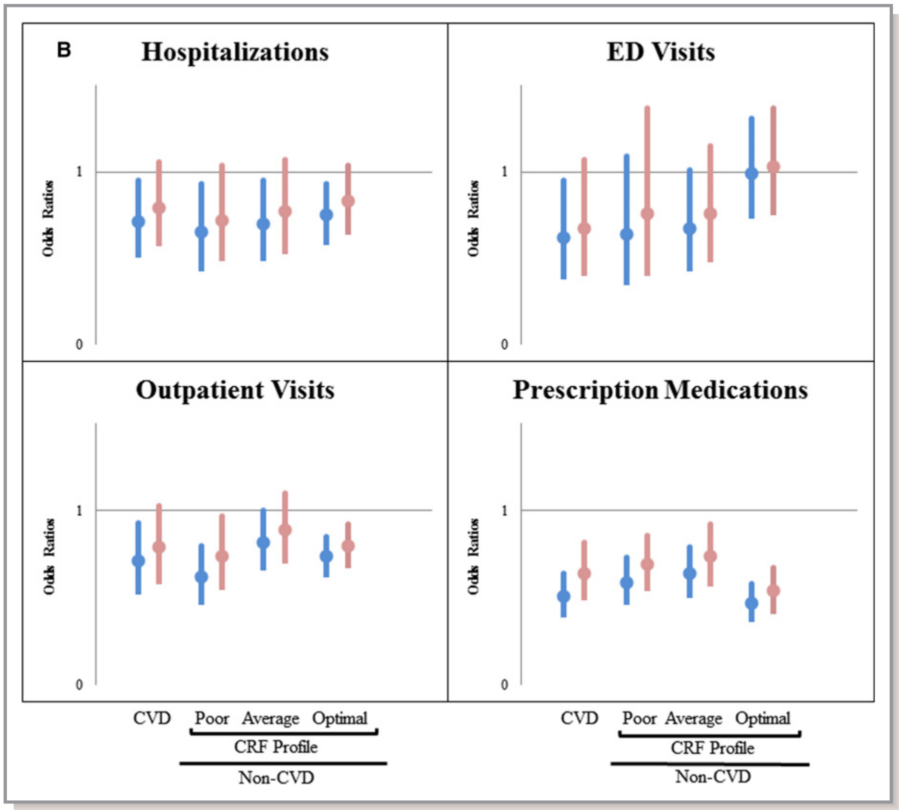

Figure 2. Continued.

activity, ≥30 minutes, ≥5 days/week (optimal vs nonoptimal). This limitation precludes the opportunity to robustly describe the interplay of reported PA levels across a wider spectrum with CVD status as well as burden of modifiable CRF on the overall health care expenditures. Given that the nonoptimal PA category likely included individuals with minimal PA, it likely resulted in more-conservative estimated differences of medical expenditures between the 2 groups. Furthermore, because of the nature of self-reported PA, there is a risk for misclassification, though likely random. As a result, this can attenuate the observed findings toward the null. It is important to note that self-reported PA has been shown to have moderate validity in other national surveys.[42] Second, as with any observational study, residual confounding is a possibility. Even though efforts were made to prevent this by controlling for most important variables, there is potential for unmeasured characteristics, which could affect our study outcomes. Third, the prevalence of CVD in this study is lower than past national estimates (9% vs 36%).[1] This is because the diagnosis of CVD in our study did not consider hypertension and instead was included in the spectrum of CRF profile assessment. Fourth, because CVD and modifiable CRF were self-reported, underestimation of the true national prevalence is likely, as has been previously described, especially with chronic conditions.[43] As a result, the estimates in our study are likely to be conservative. Because of lack of information on dietary habits, we were not able to account for this important modifiable risk factor. In addition, because of reliance on self-reported risk factors and lack of information on clinical values (eg, blood pressure), we were unable to estimate the prevalence of the AHA defined “ideal CV health status” in our study. Fifth, other analyses have found that MEPS data tend to underestimate total medical expenditures.[44–46] This limitation would lead to a likely underestimation of the actual cost associated with increasing burden of modifiable CRF as well estimating savings from primordial prevention strategies.

In conclusion, from a national representative population, we provide strong evidence of the association between moderate-vigorous PA and significantly lower health care expenditures and resource utilization, irrespective of CVD status and/or CRF burden. These robust estimates for potential health care savings strongly support the AHA’s strategic goals for optimizing PA levels as a mean to favorably impact the increasing burden of CVD and associated costs.

Disclosures

Dr Nasir is on the advisory board for Quest Diagnostic and is a consultant for Regeneron. No other potential conflicts of interest relevant to this article were reported.

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