BMI, Physical Activity, and Health Care Utilization/Costs among Medicare Retirees

Feifei Wang, Tim McDonald,† Bonnie Reffitt,‡ and Dee W. Edington**

Abstract

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Objective: To examine the influence of physical activity (PA) and BMI on health care utilization and costs among Medicare retirees.

Research Methods and Procedures: This cross-sectional study was based on 42,520 Medicare retirees in a U.S.-wide manufacturing corporation who participated in indemnity/perferred provider and one health risk appraisal during the years 2001 and 2002. Participants were assigned into one of the three weight groups: normal weight, overweight, and obese. PA behavior was classified into three levels: sedentary (0 time/wk), moderately active (1 to 3 times/wk), and very active (4+ times/wk).

Results: Generalized linear models revealed that the moderately active retirees had $1456, $1731, and $1177 lower total health care charges than their sedentary counterparts in the normal-weight, overweight, and obese groups, respectively ($p < 0.01$). The very active retirees had $1823, $581, and $1379 lower costs than the moderately active retirees. Health care utilization and specific costs showed similar trends with PA levels for all BMI groups. The total health care charges were lower with higher PA level for all age groups ($p < 0.01$).

Discussion: Regular PA has strong dose-response effects on both health care utilization and costs for overweight/obese as well as normal-weight people. Promoting active lifestyle in this Medicare population, especially overweight and obese groups, could potentially improve their well-being and save a substantial amount of health care expenditures. Because those Medicare retirees are hard to reach in general, more creative approaches should be launched to address their needs and interests as well as help reduce the usage of health care system.

Key words: overweight, older adults, exercise, medical costs, outpatient/inpatient/drug costs

Introduction

Obesity and physical inactivity are the two most prevalent health risks in western countries. Obesity is a common metabolic condition associated with many diseases such as type 2 diabetes, coronary heart disease, stroke, hypertension, gallbladder disease, some forms of cancer, sleep apnea, and osteoarthritis (1). Physical inactivity can lead to cardiovascular diseases, diabetes, and higher premature mortality rate (2–5). Health service usage is substantially higher among overweight-obese people and/or physically inactive people due to those diseases (6). Health care expenditures also increase among these people and put a huge burden on our society. On average, 2% to 7% of the total health care expenditures is attributable to overweight and obesity within western countries (7–11), and 2% to 3% is attributable to physical inactivity (12,13).

From the point of view of both the individuals' well-being and societal economic costs, people with risks should reduce their body weight and/or increase physical activity (PA)[1] levels. National statistics, however, continue to show an increasingly higher prevalence of obesity and sedentary behavior among all age groups. Although elders suffer from aging-related pains and medical conditions, health risks such as obesity and sedentary behavior result in additional

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*Health Management Research Center, University of Michigan, Ann Arbor, Michigan; †General Motors Corporation, Pontiac, Michigan; and ‡International Union, United Automobile, Aerospace, and Agricultural Implement Workers of America, Detroit, Michigan.
Address correspondence to Feifei Wang, 1027 East Huron Street. Ann Arbor, MI 48104-1688.
E-mail: feifeiw@umich.edu

[1] Nonstandard abbreviations: PA, physical activity; ER, emergency room; PPO, preferred provider; HRA, health risk appraisal; CI, confidence interval.

odds of having more and severe diseases. Among those 60 to 69 years old, the obese rate was 21.3% in 1998, representing a 45% increase since 1991. Those 70 years old or more had a relatively lower obese rate, with 14.6% in 1998 (14). According to the Centers for Disease Control and Prevention, 22.5% of those 65 years and older were never active and only 15.3% were at a high level of overall PA status in 2000 (15). Moreover, 16% of the U.S. population is 65 years and older, and the percentage is still increasing.

In general, the relationships among obesity, physical inactivity, and health care utilization or costs are well known at the whole population level. The studies addressing those relationships among elders are very few and with limited outcome measures. In a study of BMI and health care costs by Wang et al. (16), the subgroup of those 65 to 74 years old showed a clear trend of higher BMI levels associated with higher costs, and the trend disappeared in the male subgroup of 75 years old and over. Similar results were reported in another study, indicating that the relative risk of mortality from all causes and from cardiovascular disease associated with greater BMI declined when age exceeded 75 years (17). The only study on health care costs and PA among elders was administered in four nursing homes (18). The results indicated that a PA intervention among those in nursing homes (mean age 88 years) did not reduce costs of selected acute health conditions, although the functional outcomes were improved significantly.

The outcome variables in the above studies included only total costs and mortality. Total health care costs can be divided into outpatient costs, inpatient costs, and drug costs, which might have different patterns across BMI and PA levels. The use of outpatient services and hospital services might be also different. The relationships between those detailed health care utilization/costs and PA behavior and BMI levels have not yet been reported among elders. The current study was designed to explore the relationship of PA behavior (sedentary, moderately active, and very active) and BMI level (normal weight, overweight, and obese) with short-term health care utilization [number of outpatient claims, emergency room (ER) visits, and hospitalization days] and health care costs (outpatient costs, inpatient costs, and drug costs) among individuals aged 65 years and over. The total health care costs have also been examined in three age groups (65 to 69, 70 to 74, and 75+ years old).

Research Methods and Procedures

Sampling

The eligible population consisted of all retired employees and spouses from General Motors Corporation who were 65 years or older as of January 2001 and selected an indemnity or preferred provider (PPO) medical insurance plan for the years 2001 to 2002 ($N = 215{,}515$). Among the eligibles, there were 47,515 (22%) who completed at least one health risk appraisal (HRA) during 2001 and 2002. The earliest HRA was used in the analyses if more than one HRA was completed during the study period.

Among 47,515 Medicare retirees who completed an HRA, those with missing values in PA and body height/weight variables were excluded ($N = 4076$). Furthermore, those with calculated BMI < 18.5 or >60 kg/m^2 were also excluded ($N = 949$). The final sample size was 42,520.

HRA

The HRA is a questionnaire originally designed by Centers for Disease Control/Carter Center and was modified by the University of Michigan Health Management Research Center. It includes questions on health-related behaviors, psychological risks, biometric measures, personal and family medical history, self-care, and preventive service practice. A detailed explanation of HRA has been reported elsewhere (19,20), and this HRA has been utilized in over 75 peer-reviewed articles.

The main variables of interest were PA and BMI. The question on PA behavior in the HRA was described as: "In the average week, how many times do you engage in PA (exercise or work which is hard enough to make you breathe more heavily and to make your heart beat faster) that is done for at least 20 minutes? Examples include brisk walking, running, and heavy labor, e.g., chopping, lifting, digging, etc." Three levels of PA were coded as 0 times/wk, 1 to 3 times/wk, and 4+ times/wk. The three levels of PA were also named as sedentary, moderately active, and very active. The validity of a single question to measure PA behavior was tested previously (21). The test-retest correlation within 1 month on this PA question was 0.82 ($p < 0.01$) (22).

BMI was calculated from self-reported weight and height on the HRA (weight in kilograms divided by height in meters squared). The study participants were classified into three weight levels according to the National Heart, Lung, and Blood Institute's BMI criteria: normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), and obese ($\geq$30 kg/m^2). The normal-weight group served as the reference group. We did an analysis with those who did on-site measurements within 3 months after having completed the mailed HRA. The correlation of weight measures between the two calculations was 0.95 ($p < 0.001$); the corresponding number for height was 0.94. The self-reported height and weight were also demonstrated to be reliable with test-retest analyses (22,23).

The covariates included major diseases (heart problems, cancer, diabetes, past stroke, and chronic bronchitis/emphysema), chronic diseases (allergy, asthma, arthritis, and back pain), and overall health risk status, which was calculated from 10 health risk factors and had two values, low and high. The 10 health risk factors included smoking (current smoking), safety belt use ($<$100% usage), alcohol ($>$14 drinks/wk), blood pressure ($\geq$140/90 mm Hg), cholesterol

(≥240 mg/dL), high-density lipoprotein cholesterol (<35 mg/dL), illness days (> 5 d/yr), perceived physical health (fair or poor), stress (summary score high), and life satisfaction (partly satisfied or not satisfied). The validity and reliability of these risk factors were discussed previously (24). Those with zero to two of the above 10 risk factors were classified as at low risk, and those with three or more risk factors were at high risk.

Health Care Utilization and Claim Data

The detailed individual medical claims data were available, which included outpatient claims (frequency), ER visits, hospitalization days, outpatient costs, inpatient costs, and pharmaceutical costs incurred during 2 full years from January 2001 to December 2002. Inpatient claims included hospital inpatient, nursing home, skilled nursing facility, residential treatment center, residential substance abuse facility, and hospice. Outpatient claims included all other categories such as physicians' office visits and hospital outpatient visits. Number of hospitalization days was defined as sum of days (with room charge) spent in hospital.

The study population was age 65+ (as of 2001) and was covered by both Medicare and indemnity/PPO plans. The indemnity/PPO plan covered the balance beyond Medicare coverage, including drug costs. Because the Medicare payments were not available to us, the charged amounts (average of years 2001 and 2002) of the outpatient, inpatient, and pharmaceutical costs were used in the analyses. The costs in 2001 were adjusted to year 2002 dollars by using the medical consumer price index (25).

For each of the above six outcomes, those who did not file any claims were assigned zero for this outcome. The outpatient claims, drug costs, and outpatient costs had <4% zeros over a 2-year period. On the other hand, the ER visits, hospitalization days, and inpatient costs had 64% to 71% of zero costs.

Analysis

SAS 8.2 software was utilized in all analyses in this paper (SAS Institute Inc., Cary, NC; SAS Institute Inc., 1999).

Generalized linear models were utilized to compare the annual health service usage and the annual health care costs. The outpatient claims, ER visits, and hospitalization days were count data with characteristics of overdispersion (SD much greater than mean). Therefore, the negative binomial distribution was applied implicitly in the models to analyze these count data. This distribution also accounted for the high percentage of zeros in ER visits and hospitalization days.

Medical costs data (total costs and three cost components) were characterized as extremely right-skewed, heteroscedastic (variance increase with mean), and usually having a certain percentage of zero costs (~70% for inpatient costs, 4% to 5% for outpatient and drug costs). The gamma distribution (log link, with $1 added to the outcome variables) was used in the models. The covariates included gender, age, major diseases, chronic diseases, and overall health risk status. The last three variables were from the initial HRA.

With each model, the post hoc test was employed to compare the annual health service usage or the annual health care costs among different habitual PA levels within each of the three BMI groups. The PA and BMI main effects were also examined independently of each other, controlling for the other covariates mentioned above.

Results

Descriptive

The final sample size was 42,520, with an average age of 74.3 (±6.1) years and 62.5% men. Compared with HRA non-participants, the HRA participants were slightly younger (0.7 years, $p < 0.01$) and were more likely to be men (6.0 percentage points more, $p < 0.01$).

Forty-seven percent of the final sample had at least one major disease, and 70.0% had at least one chronic disease. As seen in Table 1, sedentary people were older, less likely to be men, and more likely to be at high risk for overall health risk status. The percentages of having at least one major disease or one chronic disease were significantly higher among sedentary individuals than among active individuals. The overweight and obese people tended to be comparatively younger and more likely to have major and chronic diseases.

Total Health Care Costs

The adjusted total health care costs, including drug costs, by PA and BMI level are shown in Figure 1, controlling for age, gender, major diseases, chronic diseases, and overall health risk status. The annual total health care costs ranged from $9436 [95% confidence interval (CI), $9130–$9752] for the very active normal-weight people to $12,795 (95% CI, $12,195–$13,424) for the sedentary obese people. The sedentary normal-weight individuals had $12,715 (95% CI, $12,173–$13,280) in total costs, which was $1456 ($p < 0.01$) more than the moderately active normal-weight individuals. On the other hand, the moderately active normal-weight people had $1823 more total costs ($p < 0.01$) than the very active people. Similarly, among overweight and obese groups, the sedentary retirees had $1731 and $1177 more costs, respectively ($p < 0.01$), than the moderately active retirees, who, in turn, had $581 and $1379 more costs than the very active retirees, respectively ($p < 0.01$).

Specific Health Care Costs

The relationship between each specific health care measure (outpatient, inpatient, and drug costs) and PA level was similar to the overall costs. (See Table 2) The moderately

Table 1. Demographics and health status

	PA				
	Total	**0 times/wk**	**1 to 3 times/wk**	**4+ times/wk**	***p****
N (%)	42,520 (100)	8920 (21.0)	20,572 (48.4)	13,028 (30.6)	<0.01
Age (mean ± SD)	74.3 ± 6.1	75.7 ± 6.6	74.2 ± 6.0	73.7 ± 5.9	<0.01
Men (%)	62.5	56.7	60.8	69.1	<0.01
High risk (%)	19.0	33.7	17.2	12.1	<0.01
≥One major disease (%)	47.0	56.5	45.1	43.5	<0.01
≥One chronic disease (%)	70.0	74.6	70.5	64.9	<0.01
BMI					
18.5 to 24.9 (%)	34.5	32.6	32.9	38.4	
25 to 29.9 (%)	44.9	41.1	45.6	46.6	
30+ (%)	20.6	26.3	21.5	15.0	<0.01
	BMI				
	Total	**18.5 to 24.9**	**25 to 29.9**	**30+**	***p****
N (%)	42,520 (100)	14,678 (34.5)	19,105 (44.9)	8737 (20.6)	<0.01
Age (mean ± SD)	74.3 ± 6.1	75.7 ± 6.5	74.1 ± 6.0	72.6 ± 5.4	<0.01
Men (%)	62.5	55.6	69.0	59.8	<0.01
High risk (%)	19.0	18.0	17.2	25.1	<0.01
≥One major disease (%)	47.0	42.9	46.8	54.4	<0.01
≥One chronic disease (%)	70.0	66.5	68.8	76.8	<0.01

Risk level is defined from 10 health risk factors (smoking, seat belt use, alcohol, blood pressure, cholesterol, HDL, illness days, perceived physical health, stress, and life satisfaction). Those with 0 to 2 risk factors were classified as at low risk, and those with 3+ risk factors were at high risk. Five major diseases include heart problems, cancer, diabetes, past stroke, and chronic bronchitis/emphysema. Four chronic diseases include allergy, asthma, arthritis, and back pain.
* ANOVA for age, χ^2 test for other variables.

active people had significantly lower outpatient costs than the sedentary people at both normal-weight ($765, $p < 0.05$) and overweight ($607, $p < 0.05$) levels but not at the obese level ($98, $p > 0.05$). The very active people had significantly lower outpatient costs than the moderately people across all weight groups, with the differences of $255, $245, and $559 for the three weight groups, respectively ($p < 0.05$).

In the normal-weight group, the moderately active people had $1076 lower ($p < 0.05$) inpatient costs than the sedentary people, and the very active people had $899 lower ($p < 0.05$) inpatient costs than the moderately active people. At both overweight and obese levels, the moderately and very active people had lower inpatient costs than the sedentary people ($p < 0.05$), but there were no statistically significant differences between the moderately and very active people. Across all weight groups, those who were moderately active had $170–$248 lower costs per year for drugs than sedentary people, and those who were very active had $107–$242 lower drug costs than those who were moderately active, with all of the above comparisons significant at $p < 0.05$.

Health Care Utilization

Overall, the number of outpatient claims, ER claims, and hospitalization days showed similar results as health care costs in relation to PA levels across BMI categories (Table 2). Compared with the sedentary retirees, the moderately active retirees had significantly lower numbers of outpatient claims (1.26 to 1.63), ER claims (0.07 to 0.10), and hospitalization days (0.40 to 0.87), except for the number of outpatient claims in the obese category. Compared with the moderately active retirees, the very active retirees had significantly lower numbers of outpatient claims (0.55 to 1.69) and ER claims (0.05) across all weight categories. The number of hospitalization days was lower (0.22, $p < 0.05$) among the very active people than among the moderately active people in the normal-weight group but not in the overweight and obese groups.

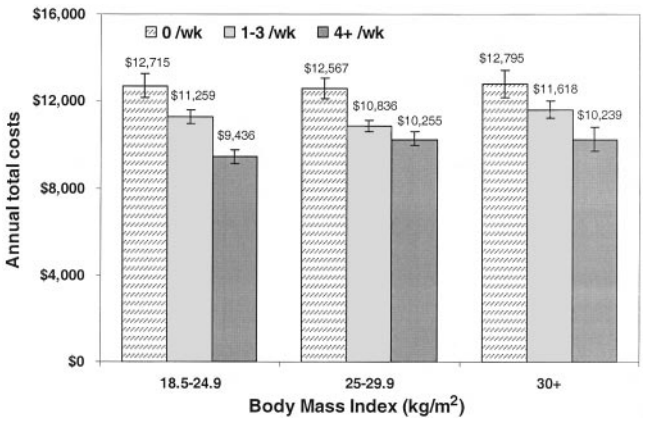

Figure 1: Adjusted total annual health care costs (including drug costs) by PA and BMI. $p < 0.01$ for any pair-wise comparisons of PA within each BMI level, controlled for gender, age, major diseases, chronic diseases, and overall health risk status. 0 times/wk, $n = 8920$; 1 to 3 times/wk, $n = 20,572$; 4+ times/wk, $n = 13,028$.

PA and BMI Main Effects on Health Care Costs

The analyses of the PA and BMI main effects revealed that the adjusted annual outpatient costs were $5286, inpatient costs $4863, and drug costs $2301 for the sedentary retirees, after controlling for other covariates (Figure 2). The moderate active retirees had $486 lower outpatient costs, $990 lower inpatient costs, and $214 lower drug costs, $p < 0.01$. The very active retirees had further lower costs in all cost categories: $353, $492, and $151, respectively ($p < 0.01$), compared with the moderately active retirees.

The BMI effects were weak compared with PA effects. The outpatient costs for the normal-weight group were $4874 after adjustment for covariates (including PA), which is not significantly different from overweight and obese groups. The inpatient costs among the obese individuals were $460 ($p < 0.01$) and $332 ($p < 0.05$) higher than among the normal-weight and overweight individuals, respectively. The drug costs were significantly different between any two weight groups ($p < 0.01$), with costs $152 and $381 higher among the overweight and obese people, respectively, than among the normal weight people, whose costs were $1931 per year.

Health Care Costs among Three Age Groups

Figure 3 shows the total health care costs by PA and BMI levels for different age groups. There were 12,077 (28.4%) people 65 to 69 years old, 12,251 (28.8%) people 70 to 74 years old, and 18,192 (42.8%) people 75 years and over. The costs decreased with higher PA levels in all age groups. Compared with the sedentary individuals, the moderately active individuals had 8% to 20% ($p < 0.01$) lower total costs across the age groups. The very active individuals had 8% to 11% ($p < 0.01$) further lower costs than the moderately active individuals. Meanwhile, the BMI-cost relationships showed a different pattern for different age groups. The only significant differences were seen between the normal-weight and overweight/obese groups in age 65 to 69 years group. The BMI levels were not related to total annual health care costs when age was >70 years.

Discussion

In summary, health care costs and utilization (outpatient claims, ER visits, and hospitalization days) were lower and fewer with higher PA levels for all of the BMI groups in Medicare retiree population. After controlling for gender, age, major diseases, chronic diseases, and overall health risk status, the moderately active retirees had $1456, $1731, and $1177 lower total health care charges than their sedentary counterparts in the normal-weight, overweight, and obese groups, respectively ($p < 0.01$). The very active retirees had $1823, $581, and $1379 lower costs than the moderately active retirees. Health care utilization and specific cost measures showed similar trends with PA levels for all BMI groups. The overall weight effects on health care costs were smaller than the PA effects in this over-65 retiree population. The total health care charges were lower with higher PA level for all age groups ($p < 0.01$), whereas the BMI-cost relationship was not evident beyond 70 years old.

Our findings indicate that over-65 individuals who do regular PA, even once a week, have fewer health problems and/or less severe health problems than totally sedentary individuals. Overweight/obese people as well as normal-weight people benefit from being physically active. Even though the PA variable was measured at one time-point, we postulate that the reported behavior, either sedentary or being active, is likely to be a long-time behavior in this Medicare retiree population. Furthermore, the effects on health care utilization and costs demonstrated in this paper are likely to be a result of long-time regular PA behaviors (sedentary or active) rather than a short-term behavior change.

With increased level of PA, most health care outcomes showed statistically significant improvement across weight groups. If sedentary people could change to be physically active at least once a week and moderately active people could become physically very active, benefits in health care expenditures should result. This dose-response effect of PA, however, should be concluded with caution. Although we controlled for some chronic diseases in our analyses, other uncontrolled health problems could lead to both sedentary behavior and high health care costs among some study people.

Our findings suggest that PA may compensate, to some extent, for the adverse effects of overweight and obesity and prevent some of the health service utilization associated with overweight and obesity among this Medicare retiree

Table 2. Adjusted annual health care utilization and costs (95% CI) by BMI and PA

	PA		
	0 times/wk (n = 8920)	**1 to 3 times/wk (n = 20,572)**	**4+ times/wk (n = 13,028)**
N			
BMI 18.5 to 24.9	2908	6765	5005
BMI 25 to 29.9	3664	9374	6067
BMI 30+	2348	4433	1956
Outpatient costs			
BMI 18.5 to 24.9	\$5488 (5243–5744)[a]	\$4723 (4585–4865)[b]	\$4468 (4316–4624)[c]
BMI 25 to 29.9	\$5380 (5168–5601)[a]	\$4773 (4654–4895)[b]	\$4528 (4385–4675)[c]
BMI 30+	\$5004 (4758–5263)[a]	\$4906 (4729–5089)[a]	\$4347 (4114–4593)[b]
Inpatient costs			
BMI 18.5 to 24.9	\$4903 (4455–5397)[a]	\$3827 (3595–4074)[b]	\$2928 (2724–3149)[c]
BMI 25 to 29.9	\$4657 (4278–5070)[a]	\$3726 (3532–3931)[b]	\$3497 (3270–3739)[b]
BMI 30+	\$5036 (4530–5598)[a]	\$4072 (3769–4399)[b]	\$3774 (3361–4238)[b]
Drug costs			
BMI 18.5 to 24.9	\$2137 (2056–2221)[a]	\$1889 (1843–1937)[b]	\$1782 (1731–1835)[c]
BMI 25 to 29.9	\$2238 (2162–2316)[a]	\$2068 (2024–2113)[b]	\$1954 (1901–2007)[c]
BMI 30+	\$2546 (2439–2657)[a]	\$2328 (2256–2401)[b]	\$2086 (1990–2186)[c]
Outpatient claims			
BMI 18.5 to 24.9	14.5 (14.1–15.0)[a]	12.9 (12.6–13.1)[b]	12.3 (12.1–12.6)[c]
BMI 25 to 29.9	14.1 (13.7–14.5)[a]	12.9 (12.6–13.1)[b]	11.9 (11.6–12.2)[c]
BMI 30+	14.1 (13.7–14.6)[a]	13.7 (13.3–14.0)[a]	12.0 (11.5–12.4)[b]
ER claims			
BMI 18.5 to 24.9	0.55 (0.52–0.58)[a]	0.45 (0.43–0.47)[b]	0.40 (0.38–0.42)[c]
BMI 25 to 29.9	0.51 (0.49–0.54)[a]	0.44 (0.42–0.45)[b]	0.39 (0.37–0.41)[c]
BMI 30+	0.56 (0.53–0.60)[a]	0.46 (0.44–0.49)[b]	0.41 (0.38–0.45)[c]
Hospitalization days			
BMI 18.5 to 24.9	1.85 (1.68–2.03)[a]	0.98 (0.92–1.05)[b]	0.76 (0.70–0.82)[c]
BMI 25 to 29.9	1.41 (1.29–1.53)[a]	0.91 (0.86–0.96)[b]	0.88 (0.82–0.94)[b]
BMI 30+	1.49 (1.34–1.66)[a]	1.09 (1.01–1.18)[b]	1.01 (0.90–1.14)[b]

All costs were adjusted to 2002 dollars.

* The different letters (a, b, or c) indicate significant difference ($p < 0.05$) among the physically active groups within each BMI level, after controlling for age, gender, major diseases, chronic diseases, and overall health risk status.

population. It is well-known that the trend toward obesity has continued to increase. A possible approach would be to promote regular PA behavior, thus indirectly controlling obesity-related health care costs. These results suggest that wellness programs could be effective in improving Medicare retirees' health status, thus substantially saving health care utilization and costs if those programs could successfully facilitate sedentary elders to graduate to PA and keep them active for the rest of their lives. However, this retiree population is typically hard to reach and will likely need creative approaches to promote effective changes in health behaviors. Community resources would be necessary for the health and well-being of those older people.

The adverse effect of overweight and obesity seems smaller than expected in this old population. Only the obese group showed higher total health care costs than the normal-weight group. There were no statistically significant differences between the normal-weight and overweight groups, nor were there any between the overweight and obese groups, although there was a trend across the three groups. This might be due to the so-called survivor issue (26,27). As seen in Table 1, the younger age of those with BMI 30+

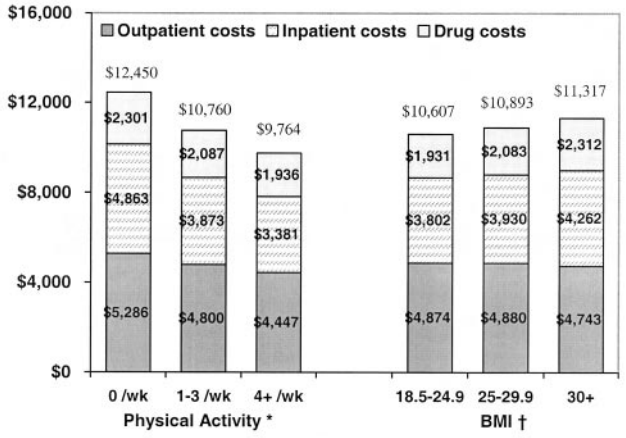

Figure 2: Adjusted annual outpatient, inpatient, and drug costs by PA and BMI. * Pair-wise comparisons among PA levels; $p < 0.01$ for any PA pairs on all outcome variables, controlled for gender, age, overall health risk status, major diseases, chronic disease, and BMI. † Pair-wise comparisons among BMI levels; $p < 0.01$ for any BMI pairs on drug costs and between the normal weight and obese groups on inpatient costs, controlled for gender, age, overall health risk status, major diseases, chronic diseases, and physical activity. $p < 0.05$ for inpatient costs between overweight and obese groups.

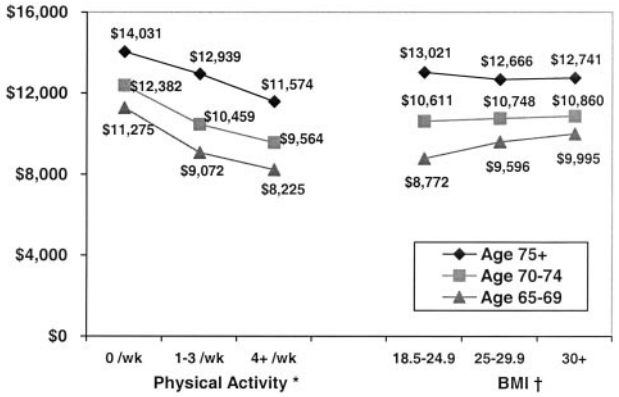

Figure 3: Adjusted annual health care costs (including drug costs) by age. * $p < 0.01$, pair-wise comparisons among PA levels within each age group, controlled for gender, age, overall health risk status, major diseases, chronic diseases, and BMI. † $p < 0.01$, pair-wise comparisons between normal weight and overweight/obese groups within age 65–69, controlled for gender, age, overall health risk status, major diseases, chronic diseases, and PA.

may be an indicator of survivor effect, and only the survivors had a chance to participate in this study. Those who survive might have adjusted better physiologically to the excess body fat than those non-survivors and, thus, had lower health care utilization and costs. Alternatively, it could also be just a fact that the health effect of excess body fat in an older population is not as much as that among younger population. More studies are needed to examine this issue.

Although the PA-cost relationships are similar across the three age groups, BMI/body weight does not show the same pattern of overall health care costs for the three age groups. For the age 65 to 69 group, the overweight/obese retirees had higher costs than their normal-weight counterparts. For ages 70 to 74, the costs of the three weight groups are not different. For age 75+, the cost trend is reversed, with the highest costs in the normal-weight group. This phenomenon suggests that the survivor effect becomes more evident in older people within this Medicare retiree population.

One of the limitations in this study is self-selection bias. The HRA participation was voluntary, which prevents generalization of our results to other populations. The HRA participants were slightly older (relatively) and more likely to be men than HRA non-participants. Although we controlled for those demographics and health risk status in our analyses, it is not possible to cover all confounders. Thus, the results should be generalized with caution, even within the Medicare retiree population.

The HRA data were self-reported data. There is always a concern about the accuracy of self-reported health behaviors, biometric measures, and health risk status. However, as explained in "Research Methods and Procedures," the major variables, PA and BMI, and other covariates are both valid and reliable. Even if some people underreported their health risks (such as lower weight and higher level PA), this would only underestimate our results and conclusions.

Some authors argue that some sedentary people cannot do PA because of physical limitations due to health problems or aging and that it is the health problems that result in both sedentary behavior and high health care costs. Nevertheless, after excluding those with physical limitations, Pratt et al. (28) found that the average annual direct medical costs were still higher among physically inactive people. In our analyses, we controlled for major chronic diseases (heart problems, cancer, diabetes, past stroke, chronic bronchitis/emphysema, allergy, arthritis, asthma, and back pain), which should eliminate some of the confounding effects of health problems.

In conclusion, our study demonstrates for the first time, to our knowledge, that lower health service usage and health care costs are associated with physically moderate and very active behavior in overweight and obese individuals 65 years and older. Physically active people utilized fewer health services and had lower health care costs than sedentary people within the same BMI categories. This indicates that the effects of physically moderate and very active behavior could offset some of the adverse effects of excess body fat. Because the number of people over 65 years old is increasing in this country and given the well-known difficulties in maintaining or losing weight, our results suggest

a promising way to control health care costs among those over 65 years, i.e., to promote regular PA behavior at least once a week, if not most days a week.

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