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Original Article

Physical activity among cancer survivors and those with no history of cancer–– a report from the National Health and Nutrition Examination Survey 2003-2006

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Abstract: Introduction: Cancer survivors are at greater risk for chronic diseases that make regular physical activity a challenge. The purpose of this manuscript was to compare physical activity levels among five-year cancer survivors and those with no history of cancer, and to determine risk factors for physical inactivity. Methods: Participants who completed the physical activity monitoring portion of the National Health and Nutrition Examination Survey (NHANES) in 2003-04 and 2005-06 were included in these analyses. Physical activity collected via accelerometer was used to determine who completed recommended amounts of physical activity according to Centers for Disease Control (CDC) guidelines. Associations between physical activity and cancer status were evaluated with multiple logistic regressions. Results: 95.5% of five-year cancer survivors and 87.3% of those with no cancer history did not meet the CDC guidelines. After adjusting for sex, age, race, education and chronic conditions, cancer survivors were 1.7 (95% CI: 1.0, 2.9) times more likely than those with no cancer history to fail to meet CDC guidelines for physical activity. Conclusions: Neither the general population nor cancer survivors met the CDC guidelines for physical activity. Cancer survivors were less likely to meet recommendations and may need tailored interventions designed to take into account comorbid conditions to increase their physical activity levels.

Keywords: Physical activity, cancer survivors, NHANES, accelerometer

Introduction

Survivors of cancer are at increased risk for the development of medical late effects as a result of their disease and its treatment. Treatments including one, or a combination of chemotherapy, radiotherapy, and surgery, while designed to eradicate the offending lesion, are often invasive and cytotoxic. Each modality has multiple potential adverse effects on long-term health ("late effects") [1]. It is estimated that there are over 11 million cancer survivors living in the United States, and with five year survival rates improving, this number will continue to increase [2]. Thus, managing the late effects of treatment with both medical and behavioral health-promoting interventions is and should be a priority [3].

Physical inactivity is a behavior that is associated with an increased risk for chronic disease. Population-based research has linked inactivity to numerous chronic conditions, including dyslipidemia [4], cardiovascular disease [4, 5], osteoporosis [6], diabetes [4, 7], obesity [8], and stroke [9]. Physical inactivity is a particular problem for cancer survivors because they are both at greater risk for chronic disease than those with no cancer history, [10] and experience a higher occurrence of physical performance limitations that make regular physical activity a challenge [11]. Recent literature has summarized evidence indicating that breast and prostate cancer survivors are at increased risk for cardiac disease [12] and osteoporosis [13]. In addition, over half (53%) of all cancer survivors report physical performance limitations

compared to one fifth (21%) of those with no history of cancer [11]. Despite their increased risk for chronic disease and physical performance limitations, intervention studies consisting of aerobic and resistance training have demonstrated that cancer survivors can benefit from regular physical activity, with improvements in quality of life [14, 15], mental health [16], muscle strength, [14] lean body mass [14], improved body composition, [16] cardiovascular performance [15, 16], and restored or increase independence [15, 16].

Recognizing that engaging in regular physical activity may be difficult for cancer survivors, we hypothesized that, when compared to members of the population without a history of cancer, cancer survivors would be less likely to participate in regular physical activity, and that those with chronic disease or physical disability would have the lowest levels of activity. To evaluate this hypothesis, these analyses had two aims. The first was to objectively (via accelerometry) enumerate the proportion of adult cancer survivors (5 years or more from diagnosis) in the United States who meet the nationally recommended guidelines for physical activity, and to compare proportions among cancer survivors and a population-based sample. The second aim was to evaluate the additional influences of chronic disease and physical performance limitations on physical activity levels.

Methods

Study population

Individuals in this analysis included persons 20 years of age and older who participated in the 2003-4 and 2005-6 National Health and Nutrition Examination Surveys (NHANES) and who completed the physical activity monitor (PAM) component of the examination. NHANES is a series of studies designed to assess the health and nutritional status of adults and children in the United States. Participants are chosen using a complex, multistage, probability sampling design to represent a sample of the civilian, non-institutionalized US population [17]. The testing protocols were approved by the National Center for Health Statistics (NCHS) ethics review board and informed consent was obtained from each participant. Our analyses included a population weighted sample representing 162,502,859 persons with no cancer history and 7, 285, 825 persons with a cancer history who were at least five years from diagnosis.

Physical activity

The primary study outcome was whether or not an individual met the Centers for Disease Control and Prevention (CDC) recommended physical activity guidelines, herein referred to as "CDC guidelines", of 30 minutes or more of moderate intensity physical activity on five days per week, or 20 minutes or more of vigorous intensity physical activity on three days per week [18]. To determine this, we used physical activity data collected with an accelerometer (ActiGraph AM-7164, ActiGraph, Fort Walton Beach, FL). [19] The device was attached to an elastic belt and worn on the right hip by participants during waking hours when not swimming or bathing [20]. Raw data were recorded as "counts", or vertical acceleration points, in one minute intervals for up to seven days, and reduced with code provided by the National Cancer Institute (available at http://riskfactor.cancer.gov/tools/nhanes_pam/). [21] These programs excluded questionable portions of data for individuals, such as extended sequences of the maximum recordable value, or periods of 60 or more minutes in which activity never returned to zero. Data were interpreted using adult intensity thresholds (2020 counts for moderate intensity corresponding with 3 metabolic equivalents [METs]) and 5999 counts for vigorous intensity (6 METs), as previously described by Troiano et al [22]. These thresholds were based on calibration studies where study participants completed treadmill or track walking at known METs while wearing the accelerometer [23, 24].

The total duration, in minutes, of moderate and/or vigorous intensity activity bouts (minimum 1 minute bouts) per day were recorded for all participants. The number of days each participant met the daily recommendations were totaled and persons were classified as meeting the recommended guidelines if they performed 30 minutes or more of moderate intensity physical activity on five days per week or 20 minutes or more of vigorous intensity physical activity on three days per week [25].

Cancer survivor status

To classify participants as five year cancer survivors or those with no history of cancer, we used the health questionnaire items medical condi-

tions questionnaire (MCQ).220: "Have you ever been told by a doctor or other health professional that you had cancer or a malignancy of any kind?", and MCQ.230: "What kind of cancer was it?, and MCQ.240: how old were you when the cancer was first diagnosed?" [26]. Participants who were less than five year survivors of cancer were excluded from the analyses as it was possible they were still receiving treatment for their cancer, potentially influencing their levels of physical activity.

Demographic characteristics and health status

Self-reported demographic and health status variables were obtained from the family questionnaire and medical conditions sections of the NHANES questionnaires [27]. Multiple variable models considered age (ten year increments), education (less than high school vs. high school graduate or greater), household income (less than $20,000 per year vs. greater than $20,000), race (black, Hispanic, other vs. white) and co-morbidities including cardiovascular disease, diabetes, a body mass index greater than 30 kilograms per meter squared, arthritis, and physical activity limitation.

Statistical analysis

Because participants in NHANES are chosen using a complex, multistage, probability sampling design [25], all analyses were done using SAS survey procedures in SAS v 9.1.3 (Cary, NC). These procedure incorporate supplied sample weights to produce unbiased national estimates. Descriptive statistics were generated and the crude association between getting the recommended amount of physical activity and cancer status was assessed using logistic regression. Multiple logistic regressions were performed adjusting for sex, age, race, household income, and co-morbidities including cardiovascular disease, diabetes, a body mass index greater than 30 kilograms per meter squared, and arthritis. Physical activity limitation was evaluated as an independent predictor of the outcome, but was not significant, so was removed from the final model.

Results

Subject characteristics

Subject characteristics are summarized in **Table 1**. Accelerometer data were analyzed on a population weighted sample representing 162,502,859 persons with no cancer history and 7, 285, 825 persons with a cancer history and at least 5 years from diagnosis. Participants, on average, wore the accelerometer for 700.2 minutes per day, for 6.6 days per week. Five-year cancer survivors were more likely than those with no history of cancer to be female, white, and to report a household income greater than $20,000. Cancer survivors were also older than those with no history of cancer (61.6 years vs. 44.9 years). Statistical comparisons revealed that all subject characteristics, with the exception of obesity, were significantly associated with cancer status.

Recommended amount of physical activity

Nearly all (95.5%) of persons who had survived five years following a cancer diagnosis and 87.3% of those without a cancer diagnosis did not meet the CDC guidelines (inactive) (**Table 2**). After adjusting for chronic conditions, race, sex, age, and educational attainment, five-year cancer survivors were 1.7 (95% Confidence Interval (CI): 1.0; 2.9) times more likely than those with no history of cancer to be inactive (**Table 2**).

Chronic disease statuses also impacted activity levels. The odds of inactivity was greatest among those with diabetes (Odds Ratio (OR): 2.9, 95% CI: 1.5; 5.8), but was also associated with obesity (OR: 2.3, 95% CI: 1.8; 2.8), cardiovascular disease (OR: 1.8; 95% CI: 1.1; 3.0) and arthritis (OR: 1.4, 95% CI: 1.1; 1.7). When analyses were stratified by cancer history, the results were similar.

Those who reported their race as black were more likely than those who reported their race as white to be inactive, while those who reported their race/ethnicity as Hispanic were more likely than those who reported their race as white to meet CDC guidelines. Females were more likely than males to be inactive. The odds of inactivity increased by 10% for every ten year increase in age. Those reporting household income less than $20, 000 per year were 1.5 times (95% Confidence Interval (CI): 1.2: 2.1) more likely to be inactive. Educational attainment was also significant predictor of inactivity; those with some college were 40% (95% Confidence Interval (CI): 20%:50%) less likely to be inactive than those who were high school gradu-

Table 1. Subject Characteristics – presented as percent (se) or mean ± se.

	Overall (n = 178,169,527)^,†	No Cancer (n = 162,502,859)^	5+ yr Survivor (n = 7,285,825)^	P value
Gender				
Male	47.4 (0.6)	48.3 (0.6)	28.9 (2.3)	<0.0001
Female	52.6 (0.6)	51.7 (0.6)	71.1 (2.3)	
Age*	46.4 ± 0.4	44.9 ± 0.4	61.6 ± 1.0	<0.0001
Education				
High School Graduate or less	43.1 (1.2)	43.0 (1.2)	47.8 (2.8)	0.0490
Some college or more	56.9 (1.2)	57.0 (1.2)	52.2 (2.8)	
Race				
White	72.6 (2.3)	71.0 (2.4)	88.4 (1.7)	<0.0001
Black	11.3 (1.4)	11.8 (1.4)	6.6 (1.4)	
Hispanic	11.3 (1.4)	12.2 (1.4)	2.8 (1.0)	
Other	4.7 (0.5)	4.9 (0.5)	2.2 (1.0)	
Income				
< $20000	15.8 (0.8)	15.4 (0.8)	22.2 (2.9)	0.0022
$20000+	84.2 (0.8)	84.6 (0.8)	77.8 (2.9)	
Co-morbidities				
CVD	7.3 (0.5)	6.2 (0.5)	15.8 (2.7)	<0.0001
Diabetes	6.5 (0.4)	6.2 (0.4)	10.7 (1.3)	0.0001
BMI 30+	33.9 (1.0)	34.3 (1.0)	34.0 (2.7)	0.8725
Arthritis	24.9 (0.9)	22.9 (0.9)	50.5 (2.7)	<0.0001
Physical limitations	28.0 (1.0)	25.4 (0.9)	54.4 (3.5)	<0.0001
Cancer type				
Breast			21.6 (2.4)	
Prostate			9.4 (1.3)	
Melanoma			9.9 (2.0)	
Uterus			5.7 (0.9)	
Thyroid			4.3 (1.5)	
Colon & rectum			4.9 (1.1)	
Lymphoma/HD			4.7 (1.9)	
Bladder			2.3 (0.5)	
Ovary			2.1 (0.8)	
Oral cavity			0.6 (0.4)	
Kidney			1.1 (0.6)	
Leukemia			0.3 (0.3)	
All other sites			33.1 (3.0)	

^ Values weighted to account for the survey design, component noncompliance, and inclusion in the analytic sample with four or more valid days. † includes those less than 5 years from cancer diagnosis. * Mean ± se. HD=Hodgkin Disease

ates or less.

Cancer type and physical activity

Ovarian cancer survivors recorded the best activity compliance with 17.9% meeting CDC guidelines. Those with other cancer types all had fewer persons who met CDC guidelines for physical activity: lymphoma 10.0%; melanoma 9.0 %; colon and rectal cancer 4.7%, prostate cancer 3.8% and breast cancer 3.7%. None of the survivors who identified their cancer types as uterine, thyroid, bladder, oral cavity, kidney, or leukemia met CDC guidelines for physical activity.

Discussion

With survival rates improving dramatically, attention must be paid to managing the late ef-

Table 2. Predictors of not meeting the recommended CDC physical activity guidelines adjusted multivariable model

	Does not meet CDC physical activity guidelines			
	Meets CDC Guidelines (n = 21,027,867) % (se)	Does not meet CDC guidelines (n=148,760,816) % (se)	Odds Ratio (95% CI)	P value
Cancer				
No History	12.7 (0.7)	87.3 (0.7)	Reference	
5+ year survivor	4.5 (1.1)	95.5 (1.1)	1.7 (1.0; 2.9)	0.0501
Gender				
Male	18.4 (0.9)	81.6 (0.9)	Reference	
Female	6.6 (0.6)	93.4 (0.6)	3.3 (2.6; 4.1)	<0.0001
Age*	40.3 ± 0.8	47.1 ± 0.5	1.1 (1.1; 1.2)	<0.0001
Education				
High School Graduate or less	9.6 (0.7)	90.4 (0.7)	Reference	
Some college or more	14.2 (0.8)	85.8 (0.8)	0.6 (0.5; 0.8)	<0.0001
Race				
White	12.3 (0.7)	87.7 (0.7)	Reference	
Black	8.7 (0.8)	91.3 (0.8)	1.3 (1.0; 1.7)	0.0286
Hispanic	16.4 (1.1)	83.6 (1.1)	0.7 (0.6; 0.9)	0.0008
Other	9.1 (1.7)	90.9 (1.7)	1.6 (0.9; 2.8)	0.1236
Income				
< $20000	7.3 (1.0)	92.7 (1.0)	1.5 (1.2; 2.1)	0.0037
$20000+	13.3 (0.7)	86.7 (0.7)	Reference	
Co-morbidities				
CVD	4.2 (0.9)	95.8 (0.9)	1.8 (1.1; 3.0)	0.0182
Diabetes	3.1 (1.0)	96.9 (1.0)	2.9 (1.5; 5.8)	0.0024
BMI 30+	6.4 (0.7)	93.6 (0.7)	2.3 (1.8; 2.8)	<0.0001
Arthritis	6.3 (0.5)	93.7 (0.5)	1.4 (1.1; 1.7)	0.0050

* Mean ± Standard Error. † OR (95% CI) corresponding to a 10 year change in age.
^ adjusted for race. OR= Odds ratio, CI= Confidence Interval, se=standard error

fects of cancer and the consequences of treatment. Physical activity and specifically designed exercise programs are an important, albeit underutilized, tool that may improve health and quality of life in cancer survivors. However, our results make it apparent that very few survivors are taking advantage of the potential benefits of physical activity. A very low proportion of survivors meet the CDC guidelines for physical activity, and presumably, even fewer engage in formal exercise programs. Our results indicate that not only do cancer survivors engage in less physical activity than the general population, but also that co-morbid medical conditions, race/ethnicity, sex, age, income, and educational attainment influence their participation rates.

The results of our analyses are in agreement with previous reports that indicate that most adults in the United States do not participate in adequate levels of physical activity [24, 28]. In addition, our reported associations between co morbid conditions, race, sex, income, age, educational attainment, obesity, and physical inactivity concur with existing literature describing these associations [24, 29, 30]. As expected, our results support the analysis of Troiano et al, who used the same 2003-2004 cohort and accelerometer recorded data to evaluate physical activity in the entire U.S. population [22]. Accelerometer recorded data suggest that Americans are much less physically active than previously thought. Previous investigations, based on self-report, estimated that 26.2% of Americans participate in recommended amounts of physical activity [24], whereas our analyses, based on accelerometer recorded data, estimated that

only 12.7% of Americans actually meet the CDC guidelines for physical activity.

Our results also concur with previously published research reporting low physical activity levels in cancer survivors [31-34]. However, there are some key differences. Our findings expand on those of Coups et al [32] and Bellizini et al [31], who reported that cancer survivors were less likely to meet the recommend levels of physical activity (25.2%, 33.0%) compared to those with no cancer history (30.8%, 35.3%). Their analyses identified this association only among survivors between 40 to 64 years of age and not among those 18 to 40 years or age. Our study showed a difference across all age groups with a linear increase in risk of not meeting the CDC guidelines with each ten year increase in age. These discrepancies can at least partially be explained by differences in population selection and study design. Approximately half of the participants in the Coups et al [32] and Bellizini et al [31] reports were less than five year cancer survivors. Our analysis excluded these individuals because of the likelihood they could still be undergoing active treatment. Acute side effects of cancer treatment modalities may influence both ability and desire to participate in physical activity. Patients receiving treatment are likely to differ from survivors who are done with the acute phase of therapy by both health concern and motivation. Therefore, we felt it important to limit our analyses to those most likely through with the acute phase of curative intervention.

Our findings are in contrast to two other studies, Eakin et al[34] and Courneya et al [33], who reported that physical activity levels did not differ among adult cancer survivors and the general populations in Australia and Canada, respectively. Both of these manuscripts included individuals with acute cancer diagnoses, and again used self-report data to estimate physical activity. Self-report data is likely less precise than measured physical activity data, and may have influenced their abilities to correctly classify activity levels in their populations.

Previous studies have reported higher rates of physical disability [11] and chronic conditions [1, 35] among cancer survivors when compared to healthy populations, so we evaluated the potential contributions of these impairments to low levels of physical activity among cancer survivors. As in previous investigations by other authors, we found that cancer survivors were more likely to report physical limitations, cardiovascular disease, diabetes, or arthritis than were members of the general population, and that co-morbid conditions were associated with low levels of physical activity. However, in our multivariate analysis, physical limitations were not associated with inactivity independent of other co-morbid conditions and body mass index. This is likely because physical disability is directly influenced by or related to other co-morbid conditions.

In our analyses, individuals who identified themselves as black were more likely to be inactive than those who reported white or Hispanic race/ethnicity. These findings are in agreement with previous reports evaluating the influence of race/ethnicity on physical activity in the general population [29, 30, 36] and among cancer survivors [11, 33, 37]. Our finding that female sex was associated with inactivity is also in agreement with previous reports of low activity levels among females when compared to males in the both the general [28] and cancer survivor populations [33, 38].

Educational attainment and household income were also significant predictors of physical activity status. Those with annual incomes less than $20,000, and those who did not get education past high school were at greater risk compared to those with annual incomes of $20,000 or more, and those who had education beyond high school to be at risk for physical inactivity. Although previous publications among cancer survivors have acknowledged and adjusted for both educational attainment and income level when examining physical activity, none have specifically reported the impact on physical activity levels in cancer survivors. Associations between income and physical activity and between educational attainment and physical activity are well established in the literature describing the general US population [36, 39]. Our data confirm that these associations do not disappear with a cancer diagnosis.

Limitations

Historically, physical activity assessment was largely measured by self-report. Accelerometers offer the chance to objectively assess physical activity levels. However with all of the promise

this tool offers, there are some limitations. First, this is a waist mounted device that records only linear acceleration. It is unable to record activities with horizontal displacement movements (i.e. swimming, cycling, etc.). If an individual's usual routine is composed of these types of activities, their total recorded minutes of physical activity would be underestimated. A second limitation of accelerometer technology is the need to use established cut points to determine the intensity of the physical activity. These cut points are based on a small number of studies in limited healthy populations [23, 24], which may be inaccurate approximations of metabolic equivalents in older individuals and/or those with mechanical or physiological adaptations (i.e. abnormal gait or decreased exercise capacity). Finally, we did use a liberal interpretation of the CDC guidelines in defining whether a person accomplished the recommended amount of physical activity. When determining the number of minutes of moderate/vigorous activity per day or week, we used "minimum 1 minute bouts" instead of "activity bouts (8 out of 10 minutes)" so we could capture both formal exercise and informal activities such as taking the stairs. Also, we credited a participant with completing "moderate" activity if 1.5 x total minutes of vigorous activity + total minutes of moderate activity was greater than or equal to 30 minutes. Though not a strict interpretation of the guidelines, we feel these modifications do not introduce bias, and more accurately represent the activity levels of most Americans.

Conclusion

Regardless of how physical activity is measured, it is clear that cancer survivors do not get enough physical activity. Because of its potential to prevent or delay the onset of many late effects of cancer treatment and improve quality of life, several reviews and organizations advocate physical activity in survivors to improve health outcomes [19, 40]. This analysis further illustrates that more needs to be done to increase physical activity in cancer survivors. The finding that co-morbid conditions are not only more common in cancer survivors, but also that they influence physical activity is particularly important [41]. Proactive prescription of exercise as a routine part of cancer survivorship and follow-up will need to be tailored to accommodate medical co-morbidities to address the unique needs of this population.

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