Original Article

Predictors of Inactive Lifestyle Among Adult Survivors of Childhood Cancer

A Report From the Childhood Cancer Survivor Study

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BACKGROUND: Participation in physical activity is important for childhood cancer survivors, because inactivity may compound cancer/treatment-related late effects. However, some survivors may have difficulty participating in physical activity, and these individuals need to be identified so that risk-based guidelines for physical activity, tailored to specific needs, can be developed and implemented. The objectives of the current study were to document physical activity patterns in the Childhood Cancer Survivor Study (CCSS) cohort, to compare the physical activity patterns with siblings in the CCSS and with a population-based sample from the Behavioral Risk Factor Surveillance System, and to evaluate associations between diagnosis, treatment, and personal factors in terms of the risk for an inactive lifestyle. **METHODS:** Percentages of participation in recommended physical activity were compared among survivors, siblings, and population norms. Generalized linear models were used to evaluate the associations between cancer diagnosis and therapy, sociodemographics, and the risk for an inactive lifestyle. **RESULTS:** Participants included 9301 adult survivors of childhood cancer and 2886 siblings. Survivors were less likely than siblings (46% vs 52%) to meet physical activity guidelines and were more likely than siblings to report an inactive lifestyle (23% vs 14%). Medulloblastoma (35%) and osteosarcoma (27%) survivors reported the highest levels of inactive lifestyle. Treatments with cranial radiation or amputation were associated with an inactive lifestyle as were being a woman, black race, older age, lower educational attainment, underweight or obese status, smoking, and depression. **CONCLUSIONS:** Childhood cancer survivors were less active than a sibling comparison group or an age- and sex-matched population sample. Survivors who are at risk for an inactive lifestyle should be considered high priority for developing and testing of intervention approaches. **Cancer 2009;115:1984–94. © 2009 American Cancer Society.**

KEY WORDS: childhood cancer, physical activity, siblings, survivorship.

The need for long-term medical follow-up and interventions to address or prevent cancer/treatment-related late effects increase as the number of individuals who survive childhood cancer continues to increase. Both individualized medical follow-up for long-term survivors of childhood cancer and the

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Received: July 29, 2008; **Revised:** September 20, 2008; **Accepted:** October 24, 2008

Published online: February 17, 2009 © 2009 American Cancer Society

DOI: 10.1002/cncr.24209, www.interscience.wiley.com

adoption of a healthy lifestyle that includes physical activity are encouraged by pediatric professional medical organizations, including the American Society of Pediatric Hematology and Oncology, the International Society of Pediatric Oncology, and the American Academy of Pediatrics.[1,2]

In the general population, physical activity decreases the risk of both all-cause mortality and mortality related to cardiovascular disease[3-8] and is associated inversely with the risk of developing breast,[9,10] endometrial,[9] colon,[11-13] and lung cancers.[14,15] Physical activity also is associated with a decreased risk of developing dyslipidemia and insulin resistance,[16] osteoporosis,[17-19] and cognitive decline.[20,21] An active lifestyle has demonstrated benefits even among those who have substantial functional loss.[22-24] Some evidence exists to support the contention that a healthy lifestyle that includes an adequate amount of physical activity has the potential to prevent or attenuate many of the long-term problems experienced by childhood cancer survivors.[25] Late effects that have been associated with an inactive lifestyle include early mortality,[26] cardiovascular disease,[27] lipid abnormalities,[28] osteoporosis,[28] cognitive decline,[29] and physical performance limitations.[30]

Because of the heterogeneous nature of histologies and treatments experienced by childhood cancer survivors, there is a need to provide a comprehensive documentation of specific risk factors for an inactive lifestyle in this population. Certain groups of cancer survivors may benefit from targeted interventions that address their unique limitations so they can modify their lifestyle choices. Others may have treatment-related late effects that are amenable to existing programs designed to improve physical health, such as those that target obesity,[31] diabetes,[32,33] or cardiovascular disease.[34] This report documents the physical activity patterns in the Childhood Cancer Survivor Study (CCSS) cohort, compares physical activity patterns between survivors and siblings, and evaluates the association between diagnosis, treatment, and demographic/personal factors and risk for inactive lifestyle. For external validation of the use of the sibling comparison group, physical activity patterns among both siblings and survivors are compared with an age- and sex-matched population reference group from the Behavioral Risk Factor Surveillance Survey (BRFSS). These analyses are designed to provide initial information for the eventual development of evidence-based, risk-based guidelines and interventions for physical activity promotion among long-term childhood cancer survivors.

MATERIALS AND METHODS

Sample

Details of the CCSS study have been published elsewhere.[35] Briefly, eligible participants were ≥5-year cancer survivors who were diagnosed between 1970 and 1986 at age <21 years at 1 of 26 institutions. Eligible diagnoses included leukemia, Hodgkin disease, non-Hodgkin lymphoma, central nervous system (CNS) malignancies, Wilms tumor, neuroblastoma, soft tissue sarcoma, and bone tumors. Of the 20,346 eligible individuals, 14,357 survivors were contacted and enrolled successfully. A comparison group of 3899 siblings also was recruited and completed the same baseline questionnaire that the survivors completed in 1995/1996. Survivor and sibling participants who completed the 2003 follow-up questionnaire had their treatment records abstracted, and those aged ≥18 years in 2003 were eligible for these analyses. The entire set of study questionnaires and the medical record abstraction form can be found at www.stjude.org/ccss accessed February 6, 2009.

Outcome of Interest

The primary outcome of interest for these analyses was activity status indicated on the 2003 CCSS Questionnaire. On the basis of participants' answers to 6 questions from the BRFSS[36] about physical activity and 1 question about participation in physical activity over the past month (Fig. 1), this outcome was summarized as 1) a binary variable that classified the participant as an individual who either met or did not meet the Centers of Disease Control and Prevention (CDC) guidelines for physical activity (30 minutes of moderate intensity physical activity on ≥5 days of the week or 20 minutes of vigorous intensity physical activity on ≥3 days of the week),[37] and 2) a binary variable that classified an *inactive lifestyle* if the participant indicated that they did not participate in any leisure-time physical activity over the past month. In addition, a 3-to-1 population-based sample was selected that was frequency matched on age and sex from individuals who

D. PHYSICAL ACTIVITY

The rest of the questions on this page are about exercise, recreation, or physical activities other than your regular job duties.

1. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, bicycling, swimming, wheelchair basketball, or walking for exercise?

☐ No ☐ Yes

We are interested in two types of physical activity: vigorous and moderate. Vigorous activities cause large increases in breathing or heart rate while moderate activities cause small increases in breathing or heart rate.

2. Now thinking about the vigorous physical activities you do in a usual week, do you do vigorous activities for at least 10 minutes at a time, such as running, aerobics, wheelchair basketball, heavy yard work, or anything else that causes large increases in breathing or heart rate?

☐ No → *Go to Question 5.*

☐ Yes

3. How many days per week do you do these vigorous activities for at least 10 minutes at a time?

☐ Days per week

4. On days when you do vigorous activities for at least 10 minutes at a time, how much total time per day do you spend doing these activities?

☐☐☐ Minutes per day

5. Now, thinking about the moderate physical activities you do in a usual week, do you do moderate activities for at least 10 minutes at a time, such as brisk walking, bicycling, vacuuming, gardening, manual operation of a wheelchair, or anything else that causes small increases in breathing or heart rate?

☐ No → *Go to next page.*

☐ Yes

6. How many days per week do you do these moderate activities for at least 10 minutes at a time?

☐ Days per week

7. On days when you do moderate activities for at least 10 minutes at a time, how much total time per day do you spend doing these activities?

☐☐☐ Minutes per day

FIGURE 1. Physical activity questions from the 2003 follow-up questionnaire.

answered the same 6 questions on the 2003 BRFSS to serve as a comparison group for both survivors and siblings.[38]

Independent (Explanatory) Variables

Diagnosis and treatment variables were abstracted from the medical record and included the following: cancer diagnosis, age at diagnosis, surgery status (classified as amputation, other surgery, or none), chemotherapy (classified as anthracyclines, other chemotherapy, or none), and radiation (classified as cranial radiation, chest radiation, other radiation, or none). Demographic and personal factors for both survivors and members of the sibling comparison group were obtained from the 2003 CCSS Questionnaire.

Explanatory variables from the 2003 CCSS Questionnaire included race, current age, highest level of educational attainment, employment status, annual household income, height and weight, smoking status, and depression. Body mass index (BMI) was calculated by dividing self-reported weight in kilograms by height in meters squared and was grouped as underweight (BMI <18.5 kg/m^2), normal weight (BMI 18.5-24.9 kg/m^2), overweight (BMI 25-29.9 kg/m^2), and obese (BMI ≥ 30 kg/m^2). Depression was assessed and classified according to the respondent's score on the 18-item Brief Symptom Inventory (BSI).[39] A T-score of ≥ 63 on the BSI was classified as depression.[40]

Statistics

Descriptive statistics were calculated for demographic and personal factors and were compared between survivors and siblings. The frequencies and percentages of survivors and siblings who did not meet CDC guidelines for physical activity and who reported an inactive lifestyle were compared in separate multivariate models, which were adjusted for demographic and personal factors. The proportion of survivors within each cancer diagnosis by sex stratification who did not meet CDC guidelines for physical activity and who reported an inactive lifestyle also were compared with the proportion of siblings in separate, age-adjusted models. All comparisons between survivors and siblings used relative risk regression models (generalized estimating equations) to account for potential intrafamily correlations.[41,42] The impact of treatment variables on not meeting CDC guidelines for physical activity and for an inactive lifestyle were evaluated in analyses that were limited to survivors only using generalized linear models

(log-link and a binomial error term)[43] stratified by sex and adjusted for age at questionnaire completion and age at diagnosis.

The frequency of survivors, siblings, and the BRFSS sample who did not meet CDC guidelines for physical activity and who reported an inactive lifestyle was calculated and compared between survivors, both overall and by diagnosis, and for the BRFSS sample using chi-square statistics. Percentages were compared between siblings and the BRFSS sample in generalized linear regression models[43] that were adjusted for age and sex.

Data were evaluated to assure that the assumptions of each procedure were met before statistical testing. Results of multivariate analyses are reported as risk ratios with 99% confidence intervals [CI]. Although analyses were hypothesis driven, because of the large sample size and the multiple comparisons conducted, confidence intervals are reported to 1 decimal place in the tables, adjusted to reflect a *P* value cutoff point of .001. SAS version 9.1 (SAS Institute, Inc., Cary, NC) was used for all analyses.

RESULTS

There were 9301 survivors and 2886 siblings who were aged ≥18 years when they completed the 2003 CCSS Questionnaire. This represents 76% of living adult survivors and siblings who were eligible to participate in this survey. Nonparticipants included 2385 survivors and 458 siblings who either actively or passively declined participation and 905 survivors and 27 siblings who were lost to follow-up. Among both survivors and siblings who completed the 2003 CCSS Questionnaire, 12,139 answered the question about inactive lifestyle (99.6%), and 11,805 (96.9%) answered the questions about physical activity. Participant survivors did not differ from nonparticipant survivors by diagnosis or age at diagnosis. Participant survivors and siblings were older, more likely to be women, and more likely to report their race as white than nonparticipant survivors or siblings ($P < .001$ for all).

The characteristics of the cancer survivors and the sibling comparison group are provided in Table 1. Cancer survivors were more likely to be men and aged ≤40 years than siblings. Siblings were more likely to have graduated from college, to be working or caring for a home and family, and to have an annual household income >$20,000. Cancer survivors were more likely than siblings to be underweight and to be never-smokers. Cancer survivors reported less exercise than siblings. Over half of cancer survivors (52%) and slightly less than half of siblings (47%) reported that they did not meet CDC guidelines for physical activity.

The associations between cancer survivor status, specific demographic and lifestyle factors, and activity status are shown in Table 2. After adjusting for demographic and lifestyle factors, cancer survivors were 1.2 times more likely (99% CI, 1.1-1.3) to report that they did not meet CDC guidelines for physical activity and 1.6 times more likely (99% CI, 1.4-1.8) to report no physical activity during the previous month (inactive lifestyle) than siblings. In the same adjusted models, being a woman, black race, older age, an inability to work, and being either underweight or obese also were associated positively with not meeting CDC guidelines for physical activity and with an inactive lifestyle. Individuals with higher levels of education were less likely to report an inactive lifestyle than those who did not finish high school. Current smokers compared with never smokers and individuals who had BSI scores ≥63 compared with those who had BSI scores <63 were more likely to report an inactive lifestyle.

Table 3 shows the associations between specific cancer diagnoses and activity status by sex. Among women, survivors of brain tumors and leukemia were the least likely to meet guidelines for physical activity. Among men, survivors of CNS tumors and osteosarcoma were the least likely to meet CDC physical activity guidelines. Both men and women survivors in every diagnostic category were more likely than siblings to report an inactive lifestyle. Amputation and cranial radiation also were associated with not meeting CDC physical activity guidelines and with an inactive lifestyle (Table 4).

Figure 2 illustrates the proportion of individuals who met CDC guidelines for physical activity and the proportion of individuals who reported no leisure-time physical activity over the past month for survivors, siblings, and the BRFSS sample. Survivors were less likely to meet the CDC guidelines for physical activity than the BRFSS reference group, and siblings were less likely to report an inactive lifestyle than the BRFSS group.

Table 1. Characteristics of the Study Population

Characteristic	Survivors, N=9301		Siblings, N=2886		
	No.	%	No.	%	*P**
Sex					
Women	4586	49.3	1548	53.6	<.0001
Men	4715	50.7	1338	46.4	
Race/ethnicity					
Non-Hispanic					
Black	332	3.6	59	2	
White	8277	89	2499	86.6	
Hispanic	394	4.2	81	2.8	<.0001
Other	262	2.8	75	5.4	
Not indicated	36	0.4	172	6	
Age group, y					
18-29	3843	41.3	1011	35	
30-39	3868	41.6	1084	37.6	<.0001
40-49	1503	16.2	682	23.6	
≥50	87	0.9	109	3.8	
Educational attainment					
<High school	439	4.7	85	3	
High school graduate	4888	52.6	1356	47	<.0001
College graduate	3874	41.7	1436	49.8	
Not indicated	100	1.1	9	0.3	
Employment					
Working/caring for home or family	7450	80.1	2628	91.1	
Student	504	5.4	124	4.3	
Unemployed/looking for work	429	4.6	68	2.4	<.0001
Unable to work	717	7.7	37	1.3	
Not indicated	201	2.2	29	1	
Annual household income, $US					
<20,000	1057	11.4	192	6.7	
≥20,000	6897	74.2	2401	83.2	<.0001
Not indicated	1347	14.5	293	10.2	
Body mass index, kg/m^2					
Underweight. <18.5	391	4.2	68	2.4	
Normal weight, 18.5-24.9	4020	43.2	1261	43.7	
Overweight, 25-29.9	2698	29	883	30.6	<.0001
Obese, ≥30	1828	19.7	587	20.3	
Height and/or weight not indicated	364	3.9	87	3	
Depression status					
Yes	870	9.4	211	7.3	.0007
No	8431	90.7	2675	92.7	
Smoking status					
Current	1468	15.8	583	20.2	
Ever	1443	15.5	643	22.3	<.0001
Never	6365	68.4	1659	57.4	
Not indicated	25	0.3	1	0.03	
Meets guidelines for physical activity					
Yes	4146	44.6	1458	50.5	
No	4847	52.1	1354	46.9	<.0001
Not indicated	308	3.3	74	2.6	
Inactive lifestyle					
No	7153	76.9	2472	85.7	<.0001
Yes	2111	22.7	403	14	
Not indicated	37	0.4	11	0.4	

* From generalized estimating equations.

Table 2. Risk Ratios and 99% Confidence Intervals Describing the Association Between Survivor Status, Sociodemographic Indicators, and Not Meeting Nationally Recommended Guidelines for Physical Activity or Reporting No Leisure-Time Physical Activity Over the Past Month (Inactive Lifestyle)

	Did Not Meet Physical Activity Guidelines: Total, N=11,805				Inactive Lifestyle: Total, N=12,139			
Characteristic	No.	%*	RR†	99% CI†	No.	%*	RR†	99% CI†
Participant group								
Siblings	2812	48.2	1.0		2875	14.0	1.0	
Survivors	8993	53.9	1.2	1.1-1.3	9264	22.8	1.6	1.4-1.8
Sex								
Women	5951	55.2	1.2	1.1-1.3	6027	21.5	1.2	1.1-1.3
Men	5854	49.8	1.0		6112	20.0	1.0	
Race/ethnicity								
Non-Hispanic								
White	10,450	51.7	1.0		10,731	20.0	1.0	
Black	367	68.7	1.2	1.2-1.3	389	35.0	1.7	1.3-2.2
Hispanic	459	56.9	1.1	1.0-1.2	474	24.3	1.1	0.9-1.5
Other	330	55.8	1.1	1.0-1.2	337	23.2	1.2	0.8-1.6
Age group, y								
18-29	4700	49.3	1.0			18.2	1.0	
30-39	4794	55.0	1.1	1.0-1.2	4842	22.6	1.5	1.3-1.7
40-49	2125	54.0	1.1	1.0-1.2	4935	21.9	1.5	1.3-1.8
≥50	186	55.4	1.2	1.1-1.4	2169	22.3	2.0	1.4-3.0
Educational attainment								
<High school	493	61.3	1.0		520	36.0	1.0	
High school graduate	5997	53.6	0.9	0.8-1.0	6227	24.6	0.8	0.6-1.0
College graduate	5213	50.1	0.9	0.8-1.1	5285	14.4	0.4	0.3-0.6
Employment								
Working/caring for home or family	9794	51.6	1.0		10,042	18.9	1.0	
Student	612	42.0	0.8	0.7-0.9	626	16.1	0.9	0.7-1.2
Unemployed/looking for work	479	56.2	1.0	0.9-1.2	494	27.1	1.3	1.0-1.6
Unable to work	712	73.2	1.2	1.1-1.3	750	43.5	2.1	1.7-2.5
Annual household income, $US								
<20,000	1197	56.4	1.0		1240	29.5	1.0	
≥20,000	9082	51.3	1.1	0.9-1.1	9272	18.6	0.8	0.7-0.9
Body mass index								
Underweight	441	60.8	1.2	1.1-1.3	457	27.1	1.5	1.2-1.9
Normal weight	5134	48.2	1.0		5265	17.9	1.0	
Overweight	3476	51.1	1.1	1.0-1.2	3562	19.0	1.0	0.9-1.2
Obese	2342	61.6	1.2	1.1-1.3	2410	26.5	1.4	1.3-1.7
Smoking status								
Current	1965	54.2	1.0	0.9-1.1	2044	27.7	1.5	1.2-1.9
Ever	2033	50.3	0.9	0.8-1.0	2075	19.0	1.0	0.8-1.1
Never	7786	52.7	1.0		7996	19.4	1.0	
Depression at time of survey								
No	10,766	52.4	1.0		10,790	20.0	1.0	
Yes	1039	54.0	1.0	0.9-1.1	1271	27.0	1.4	1.2-1.7

RR indicates risk ratio; CI, confidence interval.

* Row percentage.

† From generalized estimating equations with a binomial distribution and a log link to allow for intra-family correlation.

Table 3. Percentage of Survivors and Siblings Not Meeting the Nationally Recommended Guidelines for Physical Activity or Reporting No Physical Activity Over the Past Month (Inactive Lifestyle)

	Did Not Meet Physical Activity Guidelines: Total, N=11,805				Inactive Lifestyle: Total, N=12,139			
Variable	No.	%*	RR†	99% CI†	No.	%*	RR†	99% CI†
Women								
Siblings	1511	49.7	1.0		1543	14.3	1.0	
Acute lymphoblastic leukemia	1333	58.1	1.2	1.1-1.3	1377	25.3	1.9	1.6-2.2
Acute myeloid leukemia	127	58.3	1.2	1.0-1.4	131	19.1	1.4	1.0-2.0
Other or unspecified leukemia	83	56.6	1.2	1.0-1.4	87	25.3	1.9	1.3-2.8
Astrocytoma	355	61.4	1.3	1.1-1.4	371	26.2	1.9	1.6-2.4
Medulloblastoma, PNET	106	68.9	1.4	1.2-1.6	109	41.3	3.0	2.4-4.0
Other CNS tumor	74	55.4	1.2	0.9-1.4	77	31.2	2.3	1.6-3.2
Hodgkin lymphoma	574	51.6	1.0	0.9-1.1	581	20.5	1.3	1.1-1.6
Non-Hodgkin lymphoma	221	57.0	1.1	1.0-1.3	227	23.8	1.7	1.3-2.1
Wilms tumor (kidney tumors)	472	54.0	1.1	1.0-1.3	482	20.3	1.6	1.3-2.0
Neuroblastoma	342	53.2	1.1	1.0-1.3	354	17.5	1.4	1.1-1.8
Osteosarcoma/other bone tumor	258	59.7	1.2	1.1-1.3	265	29.8	1.9	1.5-2.4
Ewing sarcoma	113	69.0	1.4	1.2-1.6	115	22.6	1.5	1.1-2.2
Soft tissue sarcoma	382	56.8	1.2	1.1-1.3	393	23.4	1.6	1.3-2.0
Men								
Siblings	1301	46.4	1.0		1332	13.7	1.0	
Acute lymphoblastic leukemia	1314	48.0	1.1	1.0-1.2	1357	20.7	1.6	1.3-1.9
Acute myeloid leukemia	100	49.0	1.1	0.9-1.3	102	20.6	1.6	1.0-2.3
Other or unspecified leukemia	96	49.0	1.1	0.9-1.3	98	20.4	1.5	1.0-2.3
Astrocytoma	359	56.3	1.2	1.1-1.3	369	25.8	1.9	1.5-2.3
Medulloblastoma, PNET	131	64.1	1.4	1.2-1.6	139	30.2	2.3	1.7-3.0
Other CNS tumor	105	61.0	1.3	1.1-1.5	107	31.7	2.3	1.7-3.2
Hodgkin lymphoma	579	47.5	1.0	0.9-1.1	597	19.4	1.3	1.1-1.7
Non-Hodgkin lymphoma	459	53.2	1.1	1.0-1.3	473	22.6	1.6	1.3-2.0
Wilms tumor (kidney tumors)	370	46.5	1.0	0.9-1.2	386	19.7	1.6	1.2-2.0
Neuroblastoma	260	50.8	1.1	1.0-1.3	266	18.8	1.5	1.1-2.0
Osteosarcoma/other bone tumor	251	57.4	1.2	1.1-1.3	258	23.3	1.6	1.2-2.1
Ewing sarcoma	119	49.6	1.0	0.9-1.3	120	19.2	1.3	0.9-2.0
Soft tissue sarcoma	410	50.7	1.1	1.0-1.2	423	22.5	1.6	1.3-2.0

RR indicates risk ratio; CI, confidence interval; PNET, primitive neuroectodermal tumor; CNS, central nervous system.
* Row percentage.
† From generalized estimating equations with a binomial distribution and a log link to allow for intrafamily correlation: adjusted for age.

DISCUSSION

The current analysis of physical activity status among a large, heterogeneous cohort of adult survivors of childhood cancer indicates that they are less active than either the siblings in the study or the general population of similar age and sex. Although the findings are statistically significant, the percentage differences in individuals who do not meet CDC physical activity guidelines probably are not clinically meaningful. What is more important is that the prevalence of no activity over than past month is 60% higher among childhood cancer survivors compared with siblings. Our results characterize the features of survivors who are in particular need of interventions that promote physical activity. These include survivors who are women, black, older, underweight or obese, and survivors of CNS or bone tumors, especially those who received cranial radiation or underwent an amputation.

Our study population reports less physical activity than other groups of childhood cancer survivors, including adolescents and young adults,[44-46] but more physical activity than a smaller group of childhood cancer survivors comprised of nearly 50% CNS tumor survivors.[47] Keats et al[45] reported average participation in combined moderate and vigorous physical activities $\geq$5 times per week, 36 to 42 minutes per session, among 51 adolescent survivors. In that cohort, CNS tumor survivors comprised 13%, and osteosarcoma survivors comprised 8.5%. Tercyak et al[46] reported adequate physical activity among 80% of

Table 4. Percentage of Survivors Not Meeting Nationally Recommended Guidelines for Physical Activity or Reporting No Physical Activity Over the Past Month (Inactive Lifestyle) by Treatment

	Did Not Meet Physical Activity Guidelines: Total, N=8993				Inactive Lifestyle: Total, N=9264			
Variable	No.	%*	RR†	99% CI†	No.	%*	RR†	99% CI†
Women								
Surgery								
Amputation of lower limb	196	69.9	1.3	1.2-1.5	202	31.2	1.6	1.2-2.0
Other surgery	2842	56.6	1.1	1.0-1.2	2919	23.4	1.2	1.0-1.4
No surgery	1073	55.7	1.0		1100	22.2	1.0	
Not indicated	329	58.4			348	29.0		
Chemotherapy								
Chemotherapy including anthracyclines	1545	58.8	1.1	1.0-1.2	1596	24.1	1.1	1.0-1.3
Chemotherapy without anthracyclines	1695	56.3	1.0	0.9-1.1	1731	23.5	1.1	1.0-1.3
No chemotherapy	877	55.1	1.0		900	22.4	1.0	
Not indicated	323	59.1			342	28.7		
Radiation‡								
Any cranial radiation	1227	62.4	1.2	1.1-1.3	1273	28.4	1.5	1.3-1.7
Chest radiation without cranial radiation	760	54.1	1.0	0.9-1.1	774	21.7	1.0	0.8-1.2
Other radiation	694	59.2	1.1	1.0-1.2	713	23.2	1.1	0.9-1.3
No radiation	1439	52.8	1.0		1470	20.3	1.0	
Not indicated	320	59.1			339	28.6		
Men								
Surgery								
Amputation of lower limb	228	54.4	1.3	1.1-1.5	234	25.2	1.4	1.0-1.9
Other surgery	3339	50.6	1.1	1.0-1.2	3447	21.1	1.0	0.9-1.3
No surgery	543	45.3	1.0		558	20.3	1.0	
Not indicated	443	56.4			456	26.5		
Chemotherapy								
Chemotherapy including anthracyclines	1693	49.8	1.0	0.9-1.1	1742	19.2	0.8	0.7-1.0
Chemotherapy without anthracyclines	1594	49.5	1.0	0.9-1.1	1659	21.8	0.9	0.8-1.1
No chemotherapy	830	52.1	1.0		845	24.0	1.0	
Not indicated	436	56.7			449	27.0		
Radiation‡								
Any cranial radiation	1297	54.5	1.2	1.1-1.3	1344	24.6	1.3	1.1-1.6
Chest radiation without cranial radiation	681	501	1.1	1.0-1.2	699	20.3	1.0	0.9-1.3
Other radiation	793	49.3	1.0	0.9-1.1	818	19.3	1.0	0.8-1.2
No radiation	1350	46.4	1.0		1389	19.3	1.0	
Not indicated	432	56.7			445	27.2		

RR indicates risk ratio; CI, confidence interval.
* Row percentage.
† From generalized linear models with a binomial distribution and a log link: adjusted for age at diagnosis and age at interview.
‡ These categories are not mutually exclusive.

75 childhood cancer survivors ages 11 to 21 years. Just over half of those individuals were women, and 52% were leukemia survivors. Finnegan et al[44] indicated that 81% of childhood cancer survivors who were recruited over the Internet reported being physically active. Those survivors were younger (ages 18-37 years) than our cohort and mostly were well educated, Caucasian women. The proportions of CNS tumor survivors (13% vs 10%) and bone tumor survivors (8% vs 11%) in our cohort were similar to the proportions reported by Finnegan et al, respectively. A small group of adult survivors of childhood cancer in Queensland, Australia were less active, with only 36% reporting sufficient physical activity.[47] That group of individuals included a greater percentage of CNS tumor survivors (43%) and more women (61%) than our study.

Our study is the first to our knowledge reporting differences among percentages of individuals who met the nationally recommended guidelines for physical activity in a large, heterogeneous cohort of cancer survivors, siblings, and a population-based comparison group. Our study included all diagnoses in the CCSS cohort and differed from a previous CCSS report in which the analyses

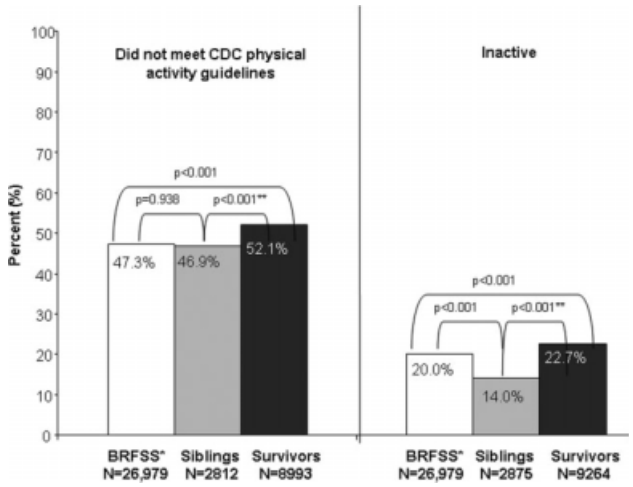

FIGURE 2. The percentage of patients who did not meet Centers for Disease Control and Prevention (CDC) guidelines for physical activity or who reported no leisure-time physical activity over the past month (inactive lifestyle) comparing survivors and siblings with an age- and sex-matched sample of the US population. A single asterisk indicates an age-matched sample; double asterisks, siblings. Behavioral Risk Factor Surveillance Survey (BRFSS) comparisons are from generalized linear models with a binomial distribution/log link adjusted for age and sex.

were limited to survivors of acute lymphoblastic leukemia.[48] Our data analyses included data summarized by Florin et al[48] and confirmed and extend the findings that being a woman and receiving cranial radiation are associated with inadequate physical activity. Our analyses also included siblings of cancer survivors, who reported physical activity levels similar to those reported in the population-based group from the BRFSS, dispelling the notion that siblings of cancer survivors who participate in research introduce either healthy or sick participant bias into the study design.[49]

The demographic and treatment-related risk factors identified in our analyses are supported by other investigators who have demonstrated lower than expected levels of physical activity among adults who were treated for CNS malignancies and bone tumors during childhood, particularly among women survivors. Odame et al[50] reported reduced physical activity levels in a group of 25 survivors of childhood CNS tumor who were ages 5 to 29 years at evaluation, with scores on 2 different activity indices lower among those who received cranial radiation compared with those who did not receive cranial radiation. Gerber et al[51] evaluated 30 survivors of pediatric sarcoma and reported that 67% had activity levels below the 50th percentile for their age and sex. Problems were most pronounced among those with lower-extremity or trunk lesions and among women.

Several study limitations should be considered in the interpretation of these results. First, physical activity was evaluated with self-report data that could not be validated. However, over- and under-reporting of physical activity were evaluated in 1 study that compared self-reported physical activity on the BRFSS survey with objective monitoring using motion sensors and a heart rate monitor.[52] The authors of that report observed 80% agreement between the 2 methods of classifying individuals who did or did not meet the national recommendations for physical activity. In addition, 2 of the personal/demographic variables in our model that influenced physical inactivity, obesity and employment status, were measured simultaneously with the physical activity outcomes. Therefore, we cannot be sure of the direction of these associations. Participants may have an inactive lifestyle because they are obese or may be obese because they have an inactive lifestyle. Participants may have an inactive lifestyle because they are busy looking for a job, or they may be unemployed and sedentary because disability prevents their participation in either activity. Finally, these analyses include cancer survivors who were treated between 1970 and 1986. Because therapy has evolved in response to the documentation of medical late effects, fewer children are receiving cranial radiation or amputation as part of treatment. Not all of our results may be generalizable to children who are treated with more contemporary therapy. However, this information is applicable to the large cohort of young adult survivors of childhood cancer who were treated on earlier protocols and to the groups of individuals who still receive chemotherapy that promotes obesity, cranial radiation, and extensive lower-extremity surgical procedures.

In summary, childhood cancer survivors were less likely than members of a sibling comparison group or an age- and sex-matched group of BRFSS survey participants to meet the nationally recommended guidelines for physical activity. Women survivors, survivors with obesity or chronic disease, survivors who received cranial radiation, and those whose treatment required extensive surgical intervention may benefit from targeted interventions that address unique barriers to participation in regular physical activity.

Conflict of Interest Disclosures

Supported by grant CA 55,727 (L. L. Robison, principal investigator) from the National Cancer Institute (Bethesda, Md) with additional support provided to St. Jude Children's Research Hospital by the American Lebanese Syrian Associated Charities.

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