Social, Demographic, and Medical Influences on Physical Activity in Child and Adolescent Cancer Survivors

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Objective This study evaluated associations between social, environmental, demographic, and medical predictors, and child and adolescent survivors' physical activity (PA). **Methods** A structured telephone survey was conducted with 105 caregiver–survivor (aged 8–16 years) pairs and 36 caregivers of younger survivors (aged 6–7 years) alone. Participants completed measures assessing survivor PA and proposed predictors of PA including demographic, medical, social, and environmental influences. **Results** Social influences, including family PA, family support for PA, and peer support for PA, emerged as unique predictors of survivor PA. These variables predicted PA after controlling for demographic and medical factors. Child survivors' PA was more strongly predicted by family influences while adolescent survivors' PA was more strongly influenced by family and peer influences. **Conclusions** Child and adolescent survivors' PA is strongly influenced by social factors. This finding parallels results with healthy children. PA interventions should focus on family and peer support to increase survivors' PA behaviors.

Key words adolescents; cancer and oncology; children; developmental perspectives; health behavior.

Introduction

Advances in medical treatment have resulted in increased survival rates for children diagnosed with cancer. At present, approximately 328,000 childhood cancer survivors live in the United States (Mariotto et al., 2009), and as many as two-thirds will experience a late effect from their diagnosis and associated treatment (Hewitt, Weiner, & Simone, 2003). At 30 years following treatment, the cumulative mortality of childhood cancer survivors from treatment-related late effects exceeds that of mortality from cancer recurrence (Armstrong et al., 2009).

Given that childhood cancer survivors are at increased risk for future health problems, it is important to foster development of health promotion behaviors that may ameliorate some of this risk. Physical activity (PA) has been targeted as a leading health promotion priority in cancer survivorship research (National Cancer Institute, 2009). Regular PA during healthy child and adolescent development is associated with increased cardiorespiratory fitness, muscle and bone strength, and more favorable cardiovascular and metabolic disease risk profiles (U.S. Department of Health and Human Services, 2008). Similar results have been found in pediatric survivors of childhood cancer (Doyle et al., 2006; Wolin, Ruiz, Tuchman, & Lucia, 2010).

Despite evidence supporting the health benefits of PA, a significant proportion of childhood cancer survivors do not meet PA recommendations (San Juan et al., 2007; Stolley, Restrepo, & Sharp, 2010; Winter, Muller, Hoffmann, Boos, & Rosenbaum, 2010). Survivor PA is generally classified according to the American Cancer Society (ACS) guidelines recommending that individuals over age 18 years engage in 30 min of moderate to vigorous activity at least five days a week (Doyle et al., 2006).

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For children and adolescents under age 18 years, ACS recommends 60 min of moderate to vigorous activity at least 5 days per week (Doyle et al., 2006). Recent reviews evaluating PA in childhood cancer suggest survivors generally report low levels of PA and are less active than healthy peers (San Juan et al., 2007, Stolley et al., 2010, Winter et al., 2010). This finding is particularly salient in light of survivors' increased risk for future health problems.

Since lifetime patterns of PA behavior are typically developed in childhood (Kohl & Hobbs, 1998; Sallis Buono, Roby, Micale, & Nelson, 1993), identifying the determinants of these behaviors in children and adolescents improves our understanding of the influence of early PA behaviors on long-term PA patterns. To date, the literature has focused primarily on late adolescent, young adult, and adult survivors of childhood cancer (Castellino et al., 2005; Cox et al., 2009; Finnegan et al., 2007; Florin et al., 2007; Keats, Culos-Reed, Courneya, & McBride, 2007), and identifies a number of factors related to engagement in PA including demographic (e.g., older age, female gender, and low socioeconomic status), medical (e.g., cranial radiation, diagnosis with CNS tumor or osteosarcoma), and psychosocial (e.g., decreased self-efficacy, negative PA beliefs, and low motivation) variables. While one might expect overlap between predictors of PA in child and adult survivors, important differences also may exist, largely due to development-driven differences in child and adult functioning, behavior, and decision-making.

Work with healthy children suggests that PA is a multidimensional behavior, resulting from intrapersonal, interpersonal, and extrapersonal influences (Heitzler et al., 2010; Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008; Sallis, Prochaska, & Taylor et al., 2000; Taylor & Sallis, 1997). PA in child and adolescent cancer survivors is complicated further with the influences of diagnosis and treatment-related factors. Several health behavior models have been cited to explain these behaviors (e.g., Theory of Planned Behavior, Interaction Model of Client Health Behavior), but these models do not take into account the social and environmental influences that may impact child and adolescent survivors' PA behaviors. The present study was guided by social ecological systems theory (Bronfenbrenner, 1979, 2001; Gilliam & Schwebel, 2011; Kazak, 1986) as this theory emphasizes the role of multiple interactive influences on behavior development and maintenance.

Research with healthy youth and adolescent survivors identifies a number of social and environmental influences on PA. In particular, greater family PA (Duncan, Duncan, Strycker, & Chaumeton, 2007; Hinkley et al., 2008; Norris, Moules, Pelletier, & Culos-Reed, 2010; Sallis et al., 2000), greater family support for PA (Gustafson & Rhodes, 2006; Heitzler, Martin, Duke, & Huhman, 2006; Sallis et al., 2000; Whitt-Glover et al., 2009), and greater peer support for PA (Heitzler et al., 2010; Strauss, Rodzilsky, Burack, & Colin, 2001; van der Horst, Chin, Paw, Twisk, & van Mechelen, 2007) are associated with higher levels of PA among these populations. Developmental differences exist such that family support is more strongly associated with children's PA while friend support is more strongly associated with adolescents' PA (Heitzler et al., 2010; Strauss et al., 2001). Research on the environmental influences on child and adolescent PA indicate that access to resources, low crime rates, and perceptions of neighborhood safety are also associated with greater levels of PA (Heitzler et al., 2006; Sallis et al., 2000; Whitt-Glover et al., 2009).

Given the proposed interactive nature of the influences on child and adolescent survivors' PA, consideration of intrapersonal influences, including demographic and medical factors, is also important. Consistent with PA patterns in healthy children, survivors who are younger, male, and from higher SES levels show higher levels of PA (Arroyave et al., 2008; Finnegan et al., 2007; Ness et al., 2009; Sallis, Taylor, Dowda, Freedson, & Pate, 2002; Tyc, Hadley, & Crockett, 2001). With regard to medical factors, diagnosis of CNS tumors or osteosarcoma and treatment with cranial radiation are associated with lower levels of PA (Arroyave et al., 2008; Florin et al., 2010; Mayer, Reuter, Dopfer, & Ranke, 2000; Nathan et al., 2009; Ness et al., 2009; Reeves, Eakin, Lawler, & Demark-Wahnefried, 2007; Winter, Muller, Hoffmann, Boos, & Rosenbaum, 2010). Mixed results have been found for the influence of age at diagnosis (Cox et al., 2009; Ness et al., 2009) and treatment-related effects (Arroyave et al., 2008; Cox et al., 2009) on survivor PA.

The purpose of the present cross-sectional study was to evaluate the association between social, environmental, demographic, and medical predictors and child and adolescent survivors' PA. It was hypothesized that social and environmental influences would predict child and adolescent survivors' PA above and beyond demographic and medical influences. Specifically, we expected that greater family PA, greater family and peer support for PA, and more favorable neighborhood characteristics would predict higher levels of survivor PA. In addition, we expected to find developmental differences in social influences on survivor PA such that child survivors' PA would be more strongly predicted by family PA and family support for PA while adolescent survivors' PA would be predicted more strongly by peer support.

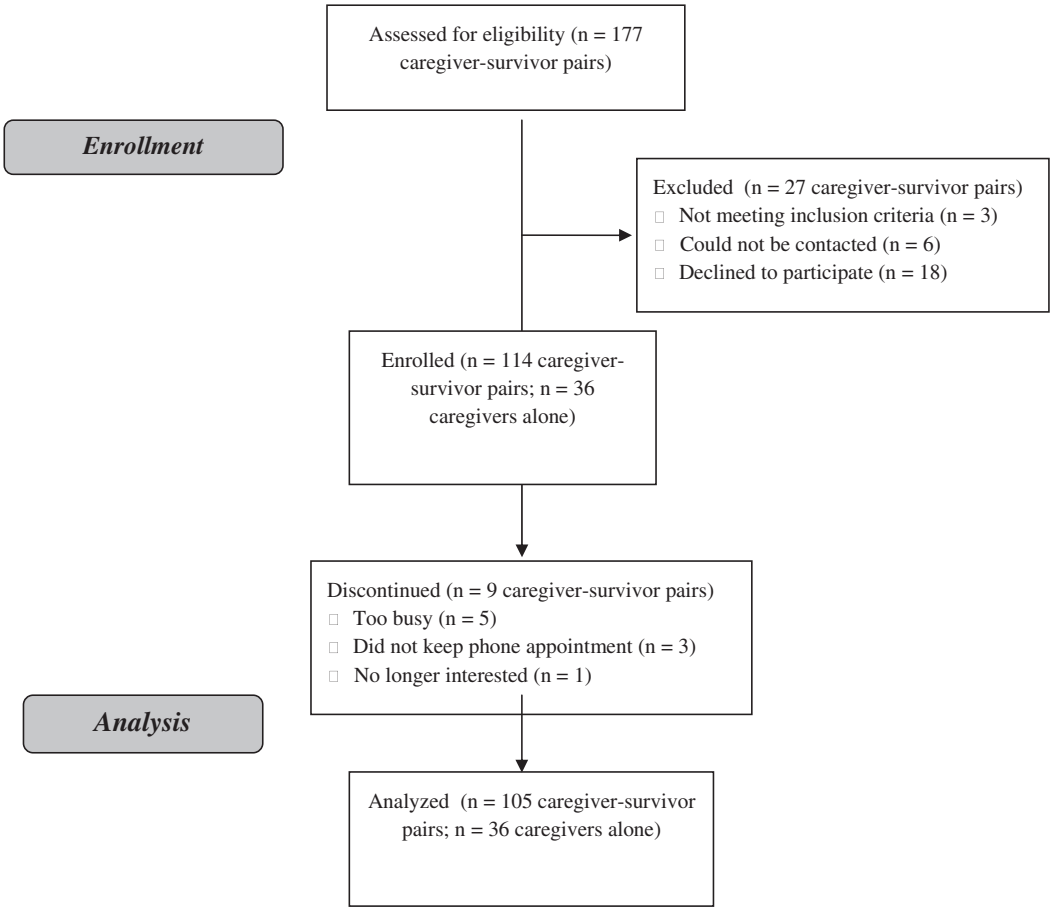

Figure 1. CONSORT flow diagram.

Methods

Participants

Participants were recruited from the University of Alabama at Birmingham (UAB), Division of Pediatric Hematology and Oncology at Children's Hospital. Inclusion criteria were children aged 6–16 years who had survived any type of cancer and were at least 1 year postcompletion of treatment. Exclusion criteria included cancer recurrence in the previous year, child residence outside of primary caregiver's home, disabilities that prohibited child or primary caregiver from completing measures orally by telephone (e.g. Down's syndrome and hearing impairment), and inability of child or primary caregiver to speak English. The study flow is summarized in Figure 1. The final sample included 105 caregiver–survivor (aged 8–16 years) pairs and 36 caregivers of younger survivors (aged 6–7 years) alone.

Survivors had a variety of cancer diagnoses, including leukemia (32%), CNS tumor (21%), soft tissue sarcoma (14%), kidney tumor (11%), non-Hodgkin's lymphoma (9%), neuroblastoma (6%), Hodgkin's disease (4%), osteosarcoma (3%), and other cancers (3%). Table I presents demographic and disease-related characteristics. There were no significant differences ($p < .05$) between survivors who completed the phone survey and those who did not based on age, gender, race, cancer diagnosis, age at diagnosis, or time since treatment.

Procedure

A telephone survey assessed direct predictors of PA in childhood cancer survivors between October 2010 and March 2011. Eligible survivors were identified through patient databases of children and adolescents treated by the UAB Division of Pediatric Hematology and Oncology at Children's Hospital since 1993. Patient records and monthly clinic lists were reviewed to verify eligibility. Eligible participants were mailed a study description approximately 2 weeks prior to contact. Following the mailing, families were approached either in the clinic ($n = 71$; 85% enrollment) or via telephone ($n = 106$;

Table I. *Descriptive Statistics (n = 141 caregivers; n = 105 survivors)*

Variable	*M* (*SD*) or %
Caregiver report	
Survivor MVPA (hours per week)	6.66 (4.49)
Survivor age (years)	11.11 (3.03)
Survivor gender	51% Male
Family income (median range)	$40,000–59,000
Ethnicity	70% Caucasian
Number of adults	1.84 (0.61)
Number of siblings	1.44 (0.21)
Sibling age difference (years)[a]	3.01 (1.90)
Family PA (standard score)	0.00 (0.95)
Family support (0–76 scale)	24.96 (11.04)
Peer support (0–12 scale)	4.58 (3.16)
Neighborhood environment (0–7 scale)	5.06 (1.39)
Survivor report	
Survivor PA (hours per week)	6.56 (4.48)
Family support (0–76 scale)	24.22 (10.70)
Peer support (0–12 scale)	4.98 (2.89)
Medical chart abstraction	
Age at diagnosis (years)	4.93 (3.61)
Time since treatment (years)	4.58 (2.88)
Treatment effects (sum of number by severity)	1.58 (1.53)
Treatment modalities	
Chemotherapy only	37%
Radiation only	0%
Surgery only	6%
Chemotherapy and radiation	17%
Chemotherapy and surgery	22%
Radiation and surgery	4%
Chemotherapy, radiation, and surgery	15%

[a]Sibling age difference represents the mean difference between the survivor and their closest-in-age sibling; this variable was deemed important as it might influence PA behavior patterns

76% enrollment) to obtain consent and arrange a time to complete the telephone survey. The university's Institutional Review Board approved all procedures.The caregiver initially completed the 20–30 min phone survey that assessed survivor PA and proposed predictors of PA including demographic characteristics, caregiver and sibling PA, family and peer support, and neighborhood influences on PA. Then, the survivor version of the survey was completed with survivors aged 8–16 years. Verbal assent was obtained first, and then a 20-min phone survey was conducted. Following completion of all surveys, the caregiver and survivor (when applicable) were each provided $10 to compensate them for their time.

Measures

Demographics

Caregivers completed a brief demographic questionnaire assessing survivor and primary caregiver characteristics including age, gender, height, weight, ethnicity, caregiver education, and family income. Information was also obtained for the number of children and adults living in the home as well as their ages.

Medical Variables

Diagnosis, age at diagnosis, number of relapses, time since treatment, treatment modalities, and treatment-related effects were abstracted from the patient's medical chart by the first author. Scoring for treatment-related effects was based on the Common Terminology Criteria for Adverse Events—Version 3.0 (CTCAE) developed through the National Cancer Institute for classifying both acute and chronic conditions in patients with cancer and survivors of all ages (Cancer Therapy Evaluation Program, 2003). Each medical late effect was scored on a 4-point scale with scores reflecting the severity of the condition. Scores were defined as follows: Grade 1, mild adverse event (AE); Grade 2, moderate AE; Grade 3, severe AE, and Grade 4, life-threatening or disabling AE. As this study evaluated living survivors of cancer, the ''Grade 5, death related to AE'' scoring criteria was not applicable. Total treatment-related effects scores were obtained by summing the severity ratings for each documented adverse event. To establish interrater reliability, 25% of participants' medical charts were independently coded by a pediatric oncology nurse practitioner in the childhood cancer survivorship program. Ratings were compared using Cohen's kappa coefficients for categorical variables and intraclass correlation coefficients for continuous variables. Coefficients ranged from .88 to 1.00. Rare disagreements were resolved through discussion.

Physical Activity

Survivors' current PA behavior was assessed through both caregiver and survivor report using a modified Leisure Score Index (LSI) from the Godin Leisure Time Exercise Questionnaire (GLTEQ; Godin & Shephard, 1985). The modified LSI assesses the frequency and duration of mild, moderate, and strenuous PA over a typical week. Behavioral descriptors and examples are provided for each of the three intensities. Intensity ratings for each activity were based on the updated Compendium of Physical Activities (Ainsworth et al., 2000). The GLTEQ has demonstrated reliability and concurrent validity based on comparisons against objective activity monitors and fitness indices including maximum oxygen consumption, forced expiratory volume, and percent body fat in children and adults (Jacobs, Ainsworth, Hartman, & Leon, 1993; Keats et al., 2007; Miller, Freedson, & Kline, 1994; Norris et al., 2010).

To calculate our primary outcome of total moderate and vigorous PA (MVPA; Bauer, Nelson, Boutelle, & Neumark-Sztainer, 2008; Sallis et al., 1993), the frequency of PA reported per week within the moderate and strenuous intensity categories were multiplied by the average reported duration. Separate scores were also calculated for total PA time and total PA metabolic equivalent (METs) hours per week using standard MET weightings (i.e., 3 METs × mild intensity frequency + 5 METs × moderate intensity frequency + 9 METs × vigorous intensity frequency).

Family Physical Activity

Caregiver and closest-in-age sibling PA were assessed using the modified LSI described above. Time spent performing MVPA was calculated for each individual. To create a family PA score, caregiver and sibling MPVA scores were standardized within the sample and then the *z*-scores were averaged to yield a measure of family PA.

Family Support for Physical Activity

Family influences on PA were measured using a 19-item scale that assessed the frequency that adults or other children in the household encouraged, supported, or engaged in PA with the survivor during a typical week (Taylor et al., 2002). Sample items included providing transportation to PA and engaging in PA with the survivor. All items were answered on a 5-point Likert scale and responses were summed to create a household support score. Scale reliability is adequate, with an internal consistency Cronbach's alpha of .78 and intraclass correlation for test–retest reliability of $r = .81$ (Sallis et al., 2002). In the current sample, Cronbach's alphas for survivor and caregiver report were $\alpha = .84$ and $\alpha = .85$, respectively.

Peer Support for Physical Activity

Peer support for survivors' PA was assessed using three items asking about frequency with which the survivor and peers encourage each other to be physically active (two items) and the frequency that peers are active with the child (one item). Items were answered on a 5-point scale, and responses summed to create a peer support score. Reliability was adequate, with internal consistency Cronbach's alpha of .74 and intraclass correlation for test–retest reliability of $r = .70$ (Sallis et al., 2002; Taylor et al., 2002). In the current sample, Cronbach's alphas for survivor and caregiver report were good, $\alpha = .88$ and $\alpha = .92$, respectively.

Neighborhood Environment

Caregivers reported on the survivors' immediate neighborhood environment using a 7-item scale (Sallis et al., 2002) that asked about the presence or absence of specific neighborhood characteristics associated with PA (e.g., sidewalks, heavy traffic, high crime, and street lights). Caregivers responded ''yes'' (1) or ''no'' (0) to whether the item was a characteristic of their neighborhood. Negative items were reverse scored and then items were summed to create a total score. Higher scores indicate more positive neighborhood characteristics that support PA. The scale has been used to evaluate neighborhood influences of PA in healthy children and adolescents and has adequate test–retest reliability ($r = .78$; Sallis et al., 2002).

Statistical Analyses

Analyses were conducted using SPSS version 19. A priori power analysis for hierarchical multiple regression with 10 predictors indicated that a sample size of 96 would be needed to reliably detect a medium effect size of .15 with alpha of 0.05 and desired statistical power level of 0.80 (Soper, 2010). Prior to the main analyses, general data screening procedures were used to identify erroneous or missing data and to evaluate the assumptions of hierarchical multiple regression. There were no missing data and all assumptions were met. Correlation analyses were performed to evaluate bivariate relations between survivor PA and the proposed predictors. To evaluate the primary hypothesis that social and environmental influences would predict survivor PA above and beyond medical and demographic influences, hierarchical multiple regression analyses were computed with MVPA as the criterion variable for each regression (supplementary analyses were conducted with alternative PA measures as a criterion). Separate analyses were conducted for caregiver- and survivor-report data. In both regressions, demographic variables were entered in Step 1, medical predictors in Step 2, and social and environmental variables in Step 3. To assess the secondary hypothesis proposing developmental differences in social influences on survivor PA, follow-up hierarchical regression models were conducted using survivor-reported data only. Separate analyses were conducted for child survivors, aged 8–11 years, and adolescent survivors, aged 12–16 years. In both regressions, gender was entered in Step 1 and social variables in Step 2. Gender was selected for inclusion in the models given the documented gender differences for time spent performing MVPA in adolescent survivors (Heath, Ramzy, & Donath, 2010).

Results

Bivariate Associations with Survivor PA

Means and standard deviations for variables of interest, including survivor MVPA, are shown in Table I.

Table II. *Correlation Matrix, All Variables of Interest*

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Survivor MVPA	–	−.08	.15	.25**	−.12	.12	−.07	.10	−.13	−.24**	.38**	.50**	.51**	.07
2. Age	−.10	–	.07	.11	−.09	.07	−.10	.11	.63**	.02	.07	−.23**	−.23	−.17*
3. Gender[a]	.20*	.08	–	−.14	.05	−.03	.00	−.03	.04	−.12	−.02	.03	.15	−.10
4. Income	.23*	.10	−.13	–	−.25**	.34*	−.03	.07	.05	.10	.36**	.31**	.13	.16
5. Ethnicity[b]	−.17	−.07	.03	.23**	–	−.26**	.13	.09	−.03	−.10	−.18*	.02	−.05	.07
6. Number of adults	.18	.07	−.03	.34**	−.26**	–	.06	−.07	.02	.02	.06	.11	−.03	−.11
7. Number of children	−.01	−.10	.00	−.03	.13	−.06	–	−.27**	−.05	.00	−.08	.06	−.08	.07
8. Sibling age difference	.09	.11	−.03	.07	.09	−.07	−.27**	–	.05	−.01	−.03	−.06	.03	−.02
9. Age at diagnosis	−.15	.63**	.05	.04	−.03	.02	−.05	.05	–	−.05	.05	−.28**	.24**	−.06
10. Treatment effects	−.21*	.02	−.12	.09	−.09	.02	.00	−.01	−.05	–	−.09	−.21**	−.30**	.05
11. Family PA	.32**	.06	−.02	.36**	−.17*	.06	−.08	−.03	.04	−.09	–	.43**	.27**	.06
12. Family support for PA	.55**	−.23*	.11	.17	−.01	.18	.15	−.05	−.27**	−.28	.32	–	.60**	.16
13. Peer support for PA	.51**	−.21	.16	.01	−.02	.01	.10	−.04	−.25**	−.32**	.21*	.61	–	.22*
14. Environment	.04	−.18*	−.10	.16	.07	−.11	.07	−.02	−.07	.04	.06	.02	.01	–

Note. Data above the diagonal reflect correlations with caregiver-reported survivor PA, $n = 141$. Data below the diagonal reflect correlations with survivor-reported PA, $n = 105$.

[a]0 = female, 1 = male

[b]0 = White, 1 = Nonwhite

*$p < .05$; **$p < .0$

According to caregiver-reported survivor MVPA, 35% of survivors did not meet the ACS recommendations for 60 min of MVPA on 5 or more days per week. Survivor-reported data yielded similar findings, with 39% of survivors reporting that they did not meet the recommendations. There were no differences in the distribution of survivors who met the recommendations versus those who did not based on cancer diagnosis. Differences were noted for age however, with older survivors reporting being less likely to meet the ACS recommendations ($p = .02$).

The relations between caregiver- and survivor-reported MVPA and the proposed predictor variables were examined using two-tailed correlation coefficients (Table II). Caregiver- and survivor-reported MVPA were strongly associated (r [103] = .85, $p = .001$). PA was significantly associated with income, treatment effects, family PA, family support for PA, and peer support for PA. Survivor-reported PA (but not caregiver-reported) was also associated with survivor gender.

Extrapersonal Predictors of Survivor PA

Separate hierarchical regression models were evaluated for caregiver-reported survivor MVPA and for survivor-reported MVPA (Table III). For each model, demographic variables (age, gender, ethnicity, and income) were entered in Step 1. Step 2 included medical variables (age at diagnosis and treatment effects) and Step 3 added the social (family PA, family support, and peer support) and environmental (neighborhood environment) variables.

In the final model based on caregiver-reported survivor MVPA, peer support for PA ($p = .002$) and family PA ($p = .04$) emerged as significant unique predictors of survivors' MVPA. Caregivers who reported higher levels of peer support of PA and greater family PA reported that their child spent a greater amount of time engaged in MVPA. While gender, income, and treatment effects were significant at Step 2, none of these variables was significant in the final model when social and environmental influences were included.

For survivor-reported MVPA, family support for PA ($p = .004$) and peer support for PA ($p = .013$) emerged as significant predictors in the final model. Survivors who reported higher levels of family support for PA and peer support for PA reported higher levels of MVPA. Similar to the caregiver data, gender, income, and treatment effects were significant at Step 2 but did not maintain predictive utility in the final model.

Social Influences on PA by Age Group

Follow-up hierarchical regression analyses evaluated differences in social influences on survivor MVPA according to survivor age. Using the survivor-reported data only, two separate analyses were conducted: first for child survivors aged 8–11 and second for adolescent survivors aged 12–16 (Table IV). In both analyses, gender was entered in Step 1 followed by the proposed social predictors (family PA, family support for PA, and peer support for PA) in Step 2.

Table III. *Summary of Hierarchical Regression Analyses for Direct Predictors of Survivors' PA (n = 141 caregivers; n = 105 survivors)*

	Step 1			Step 2			Step 3		
Variable	B	*SE*	β	B	*SE*	β	B	*SE*	β
Caregiver-reported survivor MVPA									
Age	−0.93	0.60	−.13	−0.19	0.75	−.03	0.21	0.68	.03
Gender (0 = female, 1 = male)	54.05	21.97	.20*	46.33	21.26	.17*	28.58	19.24	.11
Income	41.62	12.78	.28**	43.67	12.33	.29**	16.48	12.25	.11
Ethnicity (0 = White, 1 = Nonwhite)	−39.92	48.93	−.07	−49.79	47.19	−.09	−34.74	42.98	−.06
Age at diagnosis				−0.94	0.63	−.15	−0.32	0.57	−.05
Treatment effects				−23.65	7.05	−.26**	−9.29	6.69	−.10
Family PA							47.44	23.11	.17*
Family support for PA							4.64	2.41	.19
Peer support for PA							24.98	7.91	.29**
Environment							−6.82	14.20	−.04
R^2			0.12			0.19			0.39
F			4.46**			5.35**			8.16**
ΔR^2						0.08			0.19
ΔF						6.43**			10.18**
Survivor-reported MVPA									
Age	−1.15	0.68	−.16	−0.42	0.86	−.06	0.03	0.76	.00
Gender (0 = female, 1 = male)	67.75	24.95	.25**	61.14	24.46	.23*	40.14	21.63	.15
Income	37.68	14.46	.25*	39.31	14.12	.26**	20.06	13.45	.13
Ethnicity (0 = White, 1 = Nonwhite)	−79.47	55.56	−.14	−87.68	54.28	−.15	−77.88	47.82	−.13
Age at diagnosis				−0.92	0.72	−.15	−0.14	0.64	−.02
Treatment effects				−19.88	8.06	−.22*	−3.40	7.53	−.04
Family PA							24.84	25.06	.09
Family support for PA							7.76	2.66	.31**
Peer support for PA							24.35	7.99	.26*
Environment							5.70	15.69	.03
R^2			0.15			0.21			0.43
F			4.40**			4.31**			7.06**
ΔR^2						0.06			0.22
ΔF						3.66*			9.08**

*$p < .05$; **$p < .01$.

For child survivors aged 8–11, family PA ($p = .002$) and family support for PA ($p = .04$) emerged as significant predictors of MVPA. Specifically, child survivors who reported greater family PA and higher levels of family support for PA reported spending more time engaged in MVPA. For adolescent survivors aged 12–16, family support for PA ($p = .01$) and peer support for PA ($p = .02$) emerged as significant predictors of MVPA. Adolescents who reported higher levels of family and peer support reported spending more time engaged in MVPA.

Supplementary Analyses With Alternative PA Measures

We repeated our main analyses with the alternative PA measures of total PA time and total PA MET hours (see Supplementary Tables S1–S4 online). The three PA measures intercorrelated strongly (*r*'s range from .72 to .95), and results with the alternative PA measures were highly consistent with results using MVPA as the outcome measure.

Discussion

Contrary to previous studies of childhood cancer survivors, the present results indicate that 60% of child and adolescent survivors report engaging in recommended levels of PA, rates similar to those observed in healthy youth (Davis et al., 2011). Also consistent with healthy children and adolescents (Heitzler et al., 2006; Sallis et al., 2000; Whitt-Glover et al., 2009), social influences emerged as independent predictors of child and adolescent survivors' PA. According to both caregiver and survivor-reported data,

Table IV. *Summary of Hierarchical Regression Analyses for Social Predictors by Developmental Stage*

	Step 1			Step 2		
Variable	B	*SE*	β	B	*SE*	β
Survivor-reported MVPA (children aged 8–11 years)[a]						
Gender	39.43	33.22	.17	44.93	27.46	.19
Family PA				96.98	28.74	.40**
Family support for PA				6.44	3.10	.29*
Peer support for PA				11.98	12.76	.13
R^2		0.03			0.44	
F		1.41			8.67**	
ΔR^2					0.41	
ΔF					10.81*	
Survivor-reported MVPA (adolescents aged 12–16 years)[b]						
Gender	72.09	37.11	.25	30.20	30.97	.10
Family PA				−2.04	29.74	−.01
Family support for PA				10.23	3.90	.37*
Peer support for PA				30.23	12.61	.32*
R^2		0.06			0.42	
F		3.77			9.88**	
ΔR^2					0.36	
ΔF					9.88*	

[a] $n = 50$
[b] $n = 55$
*$p < .05$; **$p < .01$.

greater peer support was associated with higher levels of survivor PA. Family influences also emerged as significant, though differences in specific influences existed across respondents. According to caregivers, increased family PA was a stronger predictor of survivor PA while for survivors, increased family support was the stronger predictor. It is possible that caregivers underestimate the direct and indirect support for PA provided by other family members given that they do not observe all of the survivor's family interactions on a daily basis. Survivors may be more accurate reporters of family support for PA.

Results also indicated the presence of developmental differences in social predictors of survivor PA, with family influences being stronger predictors in child survivors and both family and peer influences emerging as strong predictors in adolescent survivors. Again, this is consistent with work with healthy youth (Heitzler et al., 2010; Strauss et al., 2001) and indicates that peer interactions become stronger influences on behavior as children transition to adolescence. Previous work has suggested that families of adolescent cancer survivors engage in unhealthy patterns of involvement and behavioral control (Alderfer, Navsaria, & Kazak, 2009) as a result of the cancer experience. The emergence of peer influence as a unique predictor of adolescent PA in the present study indicates that survivors follow a developmental trajectory similar to their healthy peers and may not be overly influenced by family.

An especially intriguing finding is the importance of social influences on survivors' PA over medical factors. Previous research has suggested that specific diagnosis and treatment-related variables (i.e., diagnosis of CNS or bone cancer, cranial irradiation, and amputation) were correlated with PA levels (Demark-Wahnefried et al., 2005; Mayer et al., 2000; Ness et al., 2009; Reeves et al., 2009). In the present study, treatment-related effects were associated with survivor PA, but this variable did not emerge as a significant predictor of survivor PA in the final model after social and environmental variables were included. In fact, no other diagnostic or treatment-related variables were associated with survivor PA beyond the social influences. This finding might suggest that, despite the presence of treatment-related effects, child and adolescent cancer survivors are able to gain social support from family and/or friends and overcome their medical issues to engage in PA. In our sample, approximately 65% of survivors met ACS recommendations for PA despite the fact that 74% of survivors were experiencing one or more treatment-related effects. These findings are further strengthened by the fact that results were consistent across measures of PA, including MVPA, total PA time, and total PA MET hours.

An alternative explanation for the lack of medical influence on PA is that our sample was too young to show the full influence of treatment-related effects on PA engagement. Some treatment-related effects develop years, or even decades, after a survivor has completed treatment for cancer (Oeffinger et al., 2006). Given that the present study included child and adolescent survivors ranging from 1 to 14 years off treatment, it is possible that the full range of treatment-related effects had not yet developed and was not yet influencing PA engagement.

While results of the present study are promising, several limitations should be noted. First, despite inclusion of a heterogeneous sample of child and adolescent survivors, subsets of some diagnostic or treatment categories (i.e., osteosarcoma and transplant recipients) were small and may have limited our power to detect significant relations between those factors and survivor PA. Second, the present study did not include a healthy control group and thus was not able to directly compare predictive pathways in child and adolescent survivors to those in healthy youth. Future research would benefit from a healthy control group to assess similarities and differences in predictors of PA between groups. Third, since most variables were assessed using self-report measures, results may have been biased by common method variance. Future studies should

incorporate a variety of subjective and objective measures when possible. Finally, this study utilized a cross-sectional design and thus causal inferences cannot be made. Future research should employ prospective and longitudinal designs to assess causal relations.

Overall, our findings indicate that the predictors of child and adolescent survivors' PA are similar to those of healthy youth and include family and peer influences. Future research should directly compare models of PA between child and adolescent cancer survivors and healthy youth. Interventions should incorporate family and peer components to increase PA in survivors who do not meet recommended levels. Given the noted developmental differences in social influences, interventions may be modified according to survivor age. For example, interventions for younger survivors could be delivered to the whole family, engaging family members in the prescribed exercise regimen and teaching family members skills to increase support for PA within the home environment. For adolescent survivors who are also influenced by peer support for PA, interventions may want to consider employing a ''buddy system,'' whereby survivors identify a friend with whom they can complete prescribed physical activities and gain needed support to maintain the prescribed regimen.

Supplementary Data

Supplementary Data are available at: http://www.jpepsy.oxfordjournals.org/.

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References

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., ... Leon, A. S. (2000). Compendium of physical activities: An update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise, 32*, S498–S504.

Alderfer, M. A., Navsaria, N., & Kazak, A. E. (2009). Family functioning and posttraumatic stress disorder in adolescent survivors of childhood cancer. *Journal of Family Psychology, 23*, 717–725.

Armstrong, G. T., Liu, Q., Yasui, Y., Neglia, J. P., Leisenring, W., Robison, L. L., & Mertens, A. C. (2009). Late mortality among 5-year survivors of childhood cancer: A summary from the Childhood Cancer Survivor Study. *Journal of Clinical Oncology, 27*, 2328–2338.

Arroyave, W. D., Clipp, E. C., Miller, P. E., Jones, L. W., Ward, D. S., Bonner, M. J., ... Demark-Wahnefried, W. (2008). Childhood cancer survivors' perceived barriers to improving exercise and dietary behaviors. *Oncology Nursing Forum, 35*, 121–130.

Bauer, K. W., Nelson, M. C., Boutelle, K. N., & Neumark-Sztainer, D. (2008). Parental influences on adolescents' physical activity and sedentary behavior: Longitudinal findings from Project EAT-II. *International Journal of Behavioral Nutrition and Physical Activity, 5*, 12–19.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Cambridge, MA: Harvard University Press.

Cancer Therapy Evaluation Program. (2003). *Common terminology criteria for adverse events, Version 3.0*. Bethesda, MD: National Cancer Institute.

Castellino, S. M., Casillas, J., Hudson, M. M., Mertens, A. C., Whitton, J., Brooks, S. L., ... Oeffinger, K. C. (2005). Minority adult survivors of childhood cancer: A comparison of long-term outcomes, health care utilization, and health-related behaviors from the Childhood Cancer Survivor Study. *Journal of Clinical Oncology, 23*, 6499–6507.

Cox, C. L., Montgomery, M., Oeffinger, K. C., Leisenring, W., Zeltzer, L., Whitton, J. A., ... Robison, L. L. (2009). Promoting physical activity in childhood cancer survivors: Targets for intervention. *Cancer, 115*, 642–654.

Davis, A. M., Bennett, K. J., Befort, C., & Nollen, N. (2011). Obesity and related health behaviors among urban and rural children in the United States: Data from the National Health and Nutrition Examination Survey 2003–2004 and 2005–2006. *Journal of Pediatric Psychology, 36*, 669–676.

Demark-Wahnefried, W., Werner, C., Clipp, E. C., Guill, A. B., Bonner, M., Jones, L. W., & Rosoff, P. M. (2005). Survivors of childhood cancer and their guardians. *Cancer, 103*, 2171–2180.

Doyle, C., Kushi, L. H., Byers, T., Courneya, K. S., Demark-Wahnefried, W., Grant, B., ... Andrews, K. S. (2006). Nutrition and physical activity during and after cancer treatment: An American Cancer Society guide for informed choices. *A Cancer Journal for Clinicians, 56*, 323–353.

Duncan, S. C., Duncan, T. E., Strycker, L. A., & Chaumeton, N. R. (2007). A cohort-sequential latent growth model of physical activity from ages 12 to 17 years. *Annals of Behavioral Medicine, 33*, 81–89.

Finnegan, L., Wilkie, D. J., Wilbur, J., Campbell, R. T., Zong, S., & Katula, S. (2007). Correlates of physical activity in young adult survivors of childhood cancers. *Oncology Nursing Forum, 34*, E60–E69.

Florin, T. A., Fryer, G. E., Miyoshi, T., Weitzman, M., Mertens, A. C., Hudson, M. M., ... Oeffinger, K. C. (2007). Physical inactivity in adult survivors of childhood acute lymphoblastic leukemia: A report from the childhood cancer survivor study. *Cancer Epidemiology, Biomarkers & Prevention, 16*, 1356–1363.

Gilliam, M. B., & Schwebel, D. C. (2011). Physical activity in child and adolescent cancer survivors: A review (iFirst article). *Health Psychology Review,* 1–19.

Godin, G., & Shepard, R. J. (1985). A simple method to assess exercise behavior in the community. *Canadian Journal of Applied Sport Sciences, 10*, 141–146.

Gustafson, S. L., & Rhodes, R. E. (2006). Parental correlates of physical activity in children and early adolescents. *Sports Medicine, 36*, 79–97.

Heath, J. A., Ramzy, J. M., & Donath, J. M. (2010). Physical activity in survivors of childhood acute lymphoblastic leukemia. *Journal of Paediatrics and Child Health, 46*, 149–153.

Heitzler, C. D., Martin, S. L., Duke, J., & Huhman, M. (2006). Correlates of physical activity in a national sample of children aged 9-13 years. *Preventive Medicine, 42*, 254–260.

Heitzler, C. D., Lytle, L. A., Erickson, D. J., Barr-Anderson, D., Sirard, J. R., & Story, M. (2010). Evaluating a model of youth physical activity. *American Journal of Health Behavior, 34*, 593–560.

Hewitt, M., Weiner, S. L., & Simone, J. V. (2003). *Childhood Cancer Survivorship: Improving Care and Quality of Life*. Washington, DC: National Academics Press.

Hinkley, T., Crawford, D., Salmon, J., Okely, A. D., & Hesketh, K. (2008). Preschool children and physical activity: A review of correlates. *American Journal of Preventative Medicine, 34*, 435–441.

Jacobs, D. R., Ainsworth, B. E., Hartman, T. J., & Leon, A. S. (1993). A simultaneous evaluation of 10 commonly used physical activity questionnaires. *Medicine & Science in Sports & Exercise, 25*, 81–91.

Kazak, A. (1986). Families with physically handicapped children: Social ecology and family systems. *Family Process, 25*, 265–281.

Keats, M. R., Culos-Reed, N., Courneya, K. S., & McBride, M. (2007). Understanding physical activity in adolescent cancer survivors: An application of the theory of planned behavior. *Psycho-oncology, 16*, 448–457.

Kohl, H. W., & Hobbs, K. E. (1998). Development of physical activity behaviors among children and adolescents. *Pediatrics, 101*, 549–554.

Mariotto, A. B., Rowland, J. H., Yabroff, K. R., Scoppa, S., Hachey, M., Ries, L., & Feuer, E. J. (2009). Long-term survivors of childhood cancers in the United States. *Cancer Epidemiology, Biomarkers & Prevention, 18*, 1033–1040.

Mayer, E. I., Reuter, M., Dopfer, R. E., & Ranke, M. B. (2000). Energy expenditure, energy intake and prevalence of obesity after therapy for acute lymphoblastic leukemia during childhood. *Hormone Research, 53*, 193–199.

Miller, D. J., Freedson, P. S., & Kline, G. M. (1994). Comparison of activity levels using Caltrac accelerometer and five questionnaires. *Medicine & Science in Sports & Exercise, 26*, 376–382.

Nathan, P. C., Ford, J. S., Henderson, T. O., Hudson, M. M., Emmons, K. M., Casillas, J. N., ... Oeffinger, K. C. (2009). Health behaviors, medical care, and interventions to promote healthy living in the childhood cancer survivor study cohort. *Journal of Clinical Oncology, 27*, 2363–2373.

National Cancer Institute. (2009). *National Cancer Institute Fact Sheet: Physical activity and cancer.* Retrieved from http://www.cancer.gov/cancertopics/factsheet/prevention/physicalactivity

Ness, K. K., Leisenring, W. M., Huang, S., Hudson, M. M., Gurney, J. G., Whelan, K., ... Oeffinger, K. C. (2009). Predictors of inactive lifestyle among adult survivors of childhood cancer. *Cancer, 115*, 1984–1994.

Norris, J. M., Moules, N. J., Pelletier, G., & Culos-Reed, S. N. (2010). Families of young pediatric cancer survivors: a cross-sectional survey examining physical activity level and health-related quality of life. *Journal of Pediatric Oncology Nursing, 27*, 196–208.

Oeffinger, K. C., Mertens, A. C., Sklar, C. A., Kawashima, T., Hudson, M. M., Meadows, A. T., ... Robison, L. L. (2006). Chronic health conditions in adult survivors of childhood cancer. *New England Journal of Medicine, 355*, 1572–1582.

Reeves, M., Eakin, E., Lawler, S., & Demark-Wahnefried, W. (2007). Health behaviours in survivors of childhood cancer. *Australian Family Physician, 36*, 95–96.

Sallis, J. F., Buono, M. J., Roby, J. J., Micale, F. G., & Nelson, J. A. (1993). Seven-day recall and other physical activity self-reports in children and adolescents. *Medicine & Science in Sports & Exercise, 25*, 99–108.

Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents. *Medicine & Science in Sports & Exercise, 32*, 963–975.

Sallis, J. F., Taylor, W. C, Dowda, M., Freedson, P. S., & Pate, R. R. (2002). Correlates of vigorous physical activity for children in grades 1 through 12. Comparing parent-reported and objectively measured physical activity. *Pediatric Exercise Science, 14*, 30–44.

San Juan, A. F., Fleck, S. J., Chamorro-Vina, C., Mate-Munoz, J. L., Moral, S., Perez, M., . . . Lucia, A. (2007). Effects of an intrahospital exercise program intervention for children with leukemia. *Medicine and Science in Sports and Exercise, 39*, 13–21.

Soper, D. S. (2010). The Free Statistics Calculators Website: A-priori Sample Size Calculator for Hierarchical Multiple Regression (Version 2.0). [Software], Retrieved from http://www.danielsoper.com/statcalc/calc01.aspx

Strauss, R. S., Rodzilsky, D., Burack, G., & Colin, M. (2001). Psychosocial correlates of physical activity in healthy children. *Archives of Pediatrics and Adolescent Medicine, 155*, 897–902.

Stolley, M. R., Restrepo, J., & Sharp, L. K. (2010). Diet and physical activity in childhood cancer survivors: A review of the literature. *Annals of Behavioral Medicine, 39*, 232–249.

Taylor, W. C., & Sallis, J. F. (1997). Determinants of physical activity in children. In A. P. Simopolous, & K. N. Pavlou (Eds.), *Nutrition and fitness: Metabolic and behavioral aspects in health and disease. World review of food and nutrition* (Vol. 82, pp. 159–167). Basel, Switzerland: Karger.

Taylor, W. C., Sallis, J. F., Dowda, M., Freedson, P. S., Eason, K., & Pate, R. R. (2002). Activity patterns and correlates among youth: Differences by weight status. *Pediatric Exercise Science, 14*, 418–431.

Tyc, V. L., Hadley, W., & Crockett, G. (2001). Prediction of health behaviors in pediatric cancer survivors. *Medical and Pediatric Oncology, 37*, 42–46.

U.S. Department of Health and Human Services. (2008). *Physical activity guidelines advisory committee report*. Washington, DC: U.S. Department of Health and Human Services, 2008.

van der Horst, K., Chin, A., Paw, M. J., Twisk, J. W. R., & van Mechelen, W. (2007). A brief review on correlates of physical activity and sedentariness in youth. *Medicine & Science in Sports & Exercise, 39*, 1241–1250.

Whitt-Glover, M. C., Taylor, W. C., Floyd, M. F., Yore, M. M., Yancey, A. K., & Matthews, C. E. (2009). Disparities in physical activity and sedentary behaviors among U.S. children and adolescents: Prevalence, correlates, and intervention implications. *Journal of Public Health Policy, 30*, S309–S334.

Winter, C., Muller, C., Hoffmann, C., Boos, J., & Rosenbaum, D. (2010). Physical activity and childhood cancer. *Pediatric Blood & Cancer, 54*, 501–510.

Wolin, K. Y., Ruiz, J. R., Tuchman, H., & Lucia, A. (2010). Exercise in adult and pediatric hematological cancer survivors: An intervention review. *Leukemia, 24*, 1113–1120.