Physical Activity among Lung Cancer Survivors: Changes across the Cancer Trajectory and Associations with Quality of Life

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Abstract

Background: **Regular physical activity may offer benefits to lung cancer survivors, many of whom experience quality-of-life (QOL) impairments. However, little is know about lung cancer survivors' engagement in physical activity across the cancer trajectory. The current study addressed this research gap and also examined the association between lung cancer survivors' physical activity and their QOL.**

Methods: **The study participants were 175 individuals who completed surgical treatment for early-stage non-small cell lung cancer 1 to 6 years previously. Participants completed a one-time survey regarding their current QOL and their engagement in physical activities currently, during the 6 months after treatment, and during the 6 months before diagnosis.**

Results: **Participants' reported engagement in both moderate and strenuous intensity activities was lower during the post-treatment period compared with before diagnosis and at the current time. Engagement in light intensity activities did not differ for the three time points. Almost two-thirds of participants did not engage in sufficient activity to meet national physical activity guidelines for any of the three time points. Lung cancer survivors who currently met physical activity guidelines reported better QOL in multiple domains than less active individuals.**

Conclusions: **Engagement in physical activity among lung cancer survivors is particularly low during the early post-treatment period. Current engagement in physical activity is associated with better QOL. However, most lung cancer survivors do not meet physical activity guidelines and may benefit from interventions to promote engagement in regular physical activities.** (Cancer Epidemiol Biomarkers Prev 2009;18(2):664–72)

Introduction

Lung cancer is the top cause of cancer mortality in the United States (1). Individuals diagnosed with regional or distant disease have 5-year survival rates of 20.6% and 2.8%, respectively (2). However, among the 16% of lung cancer patients who are diagnosed with localized disease, the 5-year survival rate is 49.5% (2). Most long-term survivors of lung cancer are diagnosed with early-stage non-small cell lung cancer, for which the primary treatment is surgical resection.

During the acute postoperative period, lung cancer survivors commonly experience symptoms such as pain, dyspnea, and fatigue, and impairments in multiple quality-of-life (QOL) domains are evident (3). Although for many individuals, particularly those who remain free of disease, these acute symptoms and impairments gradually improve, deficits in psychological well-being, physical functioning, and role functioning may persist for several years (4). Lung cancer is largely a disease of older adults, with a median age at diagnosis of 71 years (2). Smoking is the leading cause of lung cancer (5), and many lung cancer survivors have comorbid medical conditions (6).

In tandem with the increasing number of cancer survivors, there has been growing interest in documenting and promoting health-enhancing lifestyle behaviors among survivors. There are multiple potential beneficial effects of physical activity for cancer survivors, including improved cardiorespiratory fitness, body composition, physical functioning, fatigue, vigor, and mood (7-9). There is a small amount of research examining physical activity among individuals with lung cancer. Low preoperative exercise capacity among lung cancer patients is associated with a longer postoperative hospital stay (10), and preoperative exercise training or pulmonary rehabilitation has been found to improve patients' cardiorespiratory fitness, functional ability, and pulmonary function (11-13). Small studies of inpatient pulmonary rehabilitation programs for postoperative lung cancer patients have found positive effects on functional ability, peak exercise capacity, and dyspnea (14, 15). In a study of lung cancer survivors at least 5 years postdiagnosis, greater motivational readiness for physical activity was associated with better symptom control and QOL (assessed using single-item questions; ref. 16).

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The results of prior research suggest that lung cancer survivors may benefit from engaging in regular physical activity. However, there is a lack of knowledge regarding potential changes in lung cancer survivors' physical activity across the cancer trajectory, and the degree to which physical activity is associated with QOL among short-term survivors of lung cancer is unknown. We addressed these issues in the current study. Specifically, in a cross-sectional survey of non-small cell lung cancer survivors, we examined reported levels of physical activity for three time points (during the 6 months before diagnosis, during the 6 months after treatment, and at the current time). We anticipated that reported levels of activity would be lower during the post-treatment period compared with before diagnosis and at the current time. We also examined associations between current physical activity and QOL, with the expectation that more active individuals would report better QOL.

Materials and Methods

Participants and Procedure. After obtaining institutional review board approval, a sample of 514 potentially eligible individuals was identified from clinical and research databases at Memorial Sloan-Kettering Cancer Center. Eligibility criteria included diagnosis of primary pathologic stage IA or IB non-small cell lung cancer, receipt of surgical resection for non-small cell lung cancer, from 1 to 6 years post-treatment, no current evidence of cancer, and oncology treating physician permission to contact the individual. An initial review of medical records revealed that 191 of these 514 individuals were ineligible (see below for full ineligibility data). We mailed a consent form and letter inviting study participation to the remaining 323 potential participants, which was followed up 2 weeks later with a telephone call. Individuals who could not be reached by telephone were mailed another invitation letter. Ultimately, a total of 239 of the 514 potentially eligible individuals were found to be ineligible for study participation. The primary ineligibility reasons were current evidence of cancer (n = 73), being >6 years post-treatment (n = 49), deceased (n = 31), or diagnosed with pathologic stage II to IV disease (n = 30). Of the remaining 275 individuals, 175 provided informed consent and participated in the study (response rate = 63.6%). Reasons for study nonparticipation were as follows: passive refusal (n = 32), unable to reach by telephone (n = 28), no reason provided (n = 12), not interested (n = 11), not wishing to talk about lung cancer (n = 11), current medical issues (n = 5), and unable to recall previous activity level (n = 1).

Most participants (n = 148) completed the survey as a telephone interview, with the remainder (n = 27) completing a mailed paper and pencil survey. Results of a series of independent samples t tests and χ^2 tests indicated that individuals completing the questionnaire by mail were less likely to be currently employed (χ^2 = 12.65; P = 0.013), were older (t = 2.39; P = 0.018), and reported a lower level of education (χ^2 = 9.04; P = 0.029) than those completing a telephone interview, but they did not differ on the other demographic factors or any of the medical characteristics listed in Measures.

Measures

Demographics. Participants reported their gender, age, race/ethnicity, education, marital status, and employment status.

Medical Characteristics. Electronic databases and medical charts were examined to obtain data on pathologic stage, preoperative pulmonary function [assessed using forced expiratory volume in the first second (FEV1) % predicted], time since treatment completion, type of treatment received, type of surgical resection, length of hospital stay after surgical resection, and presence of postresection complications. Participants completed questions about their current and prior smoking, their current height and weight (from which body mass index was calculated), and their current comorbid medical conditions (17).

QOL. We used multiple self-report measures to fully assess lung cancer survivors' QOL. Participants completed the SF-36v2 (18), which includes subscales assessing eight dimensions of QOL (α values = 0.74-0.95 in the current study): physical functioning, role limitations due to physical problems, bodily pain, general health perceptions, vitality, social functioning, mental health, and role limitations due to emotional problems. Consistent with the SF-36v2 scoring instructions, subscale scores were calculated as norm-based T scores (18). Dyspnea and fatigue were measured using the 3-item Baseline Dyspnea Index (α = 0.91; ref. 19) and 9-item Brief Fatigue Inventory (α = 0.94; ref. 20), respectively. Anxiety and depression symptoms were assessed using the 14-item Hospital Anxiety and Depression Scale (anxiety subscale α = 0.82 and depression subscale α = 0.77; ref. 21).

Physical Activity. We used a modified version of the Godin Leisure-Time Exercise Questionnaire (22) to measure participants' reported physical activity for three time points: during the 6 months before diagnosis of non-small cell lung cancer, during the 6 months after treatment completion, and at the current time. For each time point, participants reported their weekly frequency and average number of minutes spent engaging in each of light (e.g., easy walking), moderate (e.g., brisk walking), and strenuous leisure-time activities (e.g., running). For each time point, we calculated the number of minutes per week participants engaged in each type of activity. We classified individuals as being sedentary if they reported engaging in no light, moderate, or strenuous physical activities. For each time point, we denoted individuals as meeting national physical activity guidelines if they reported engaging in at least 60 min of strenuous activity or ≥150 min of at least moderate intensity activities per week (23). The Godin Leisure-Time Exercise Questionnaire has good test-retest reliability, has shown convergent validity with objective and other self-report physical activity measures (24), and has been used in prior studies of physical activity in cancer survivors (25-27).

Statistical Analysis. We conducted a series of independent samples t tests and χ^2 tests to examine potential differences in demographic and medical characteristics between individuals who participated in the study and those who declined participation. For each of the

continuous physical activity variables (weekly minutes of light, moderate, and strenuous activity), we used linear regression models estimated by generalized estimating equations assuming unstructured correlation matrices to examine whether activity varied across the three time points. We used robust SEs to account for the non-normality of the physical activity variables. We confirmed that the time main effects were similar when fitting generalized linear models assuming gamma distributions and log links. The gamma models provide more appropriate distributional assumptions for our nonnegative and skewed physical activity data, but the model parameters are not as readily interpretable as those in the linear models we report. For the dichotomous physical activity variables (whether individuals were sedentary and whether they met physical activity guidelines), we examined changes across the three time points using logistic regressions estimated by generalized estimating equations with unstructured correlation structures and robust SEs.

To examine whether changes in activity across the three time points varied according to select demographic or medical factors, we repeated each of the linear and logistic regression analyses including interactions terms of each demographic/medical factor with time (pre-diagnosis, post-treatment, and current time). Given the lack of prior research on factors associated with physical activity changes among lung cancer survivors, we examined a comprehensive set of demographic and medical factors in the aforementioned analyses: gender, age, pathologic stage, preoperative pulmonary function, time since treatment, type of surgical resection, length of hospital stay postresection, number of surgical complications, current smoking status, current weight status, and number of current comorbid medical conditions. We also report the patterns of activity in terms of meeting/not meeting activity guidelines across the three time points.

To further examine how individuals' current level of physical activity varied as a function of their level of activity before diagnosis and during the post-treatment period, we examined cross-tabulations of individuals' current activity status (whether sedentary, engage in some activity but below guideline levels, or meet physical activity guidelines) with their pre-diagnosis and post-treatment activity status. We used a series of linear regression analyses with robust SEs to examine potential differences in QOL according to individuals' current physical activity status. We also conducted these linear regression analyses while controlling for all of the demographic and medical variables. All statistical analyses were two-sided and a cutoff of $P < 0.05$ was used to determine statistical significance.

Results

Comparison of Study Participants and Individuals Who Declined Participation. Individuals who declined study participation did not differ from study participants with regard to age, gender, pathologic stage, preoperative pulmonary function, time since treatment completion, type of surgical resection, length of hospital stay, or number of post-resection complications (t values ≤ 1.42, χ^2 values ≤ 5.58, P values ≥ 0.114).

Table 1. Demographic characteristics of lung cancer survivor sample (n = 175)

	Sample (%)
Gender	
Male	36.6
Female	63.4
Missing (n)	0
Age, y (mean = 68.73, SD = 9.62)	
39-59	16.6
60-69	31.4
70-79	42.9
80-89	9.1
Missing (n)	0
Race/ethnicity	
Non-Hispanic White	92.6
Non-Hispanic Black	3.4
Non-Hispanic Asian/Pacific Islander	2.3
Non-Hispanic other	0.6
Hispanic	1.1
Missing (n)	0
Education	
High school graduate or less	29.9
Some college	20.1
College graduate	24.7
Graduate degree	25.3
Missing (n)	1
Married/partnered	
No	37.7
Yes	62.3
Missing (n)	0
Employment status	
Employed	32.4
Homemaker	6.4
Unemployed	3.5
Retired	53.8
Unable to work	4.1
Missing (n)	2

Sample Demographic and Medical Characteristics. Participants' demographic characteristics are shown in Table 1. Almost two-thirds of participants were female, half were ages ≥70 years, almost all were White, and most had at least some college education. The medical characteristics of the sample are shown in Table 2. Almost all participants were treated with surgery alone and lobectomy was the most common surgical procedure. Few participants (5.8%) reported currently smoking, although 79.8% were former smokers.

Prevalence of Physical Activity across Time Points. As shown in Table 3, reported levels of light activity did not differ significantly across the three time points and averaged ~80 min/wk. However, reported levels of moderate activity significantly decreased from pre-diagnosis to post-treatment and increased significantly from post-treatment to the current time. Current levels of moderate activity did not differ significantly from those reported for the pre-diagnosis period. Levels of strenuous intensity activity followed the same pattern as for moderate activity, although the mean number of weekly minutes of strenuous activity was low for all three time points (from a high of 24.5 min for the pre-diagnosis period to 8.1 min for the post-treatment period). The percentage of participants who were sedentary (no reported engagement in light, moderate, or strenuous intensity activities) did not differ significantly across the three time points and varied from 1 in 5 participants at

Table 2. Medical characteristics of lung cancer survivor sample (n = 175)

	Sample (%)	Mean (SD)
Pathologic stage		
IA	69.7	
IB	30.3	
Missing (n)	0	
Preoperative FEV1 (% predicted)		89.66 (19.37)
40-59	8.1	
60-79	18.5	
80-99	42.8	
100-119	24.3	
120-139	6.4	
Missing (n)	2	
Years since treatment completion		3.62 (1.23)
1 to <2	8.0	
2 to <3	29.7	
3 to <4	26.3	
4 to <5	20.0	
5 to <6	16.0	
Missing (n)	0	
Treatment received		
Surgery only	91.4	
Surgery + neoadjuvant chemotherapy	5.7	
Surgery + adjuvant chemotherapy	2.3	
Surgery + adjuvant radiation therapy	0.6	
Missing (n)	0	
Type of surgical resection		
Wedge	8.0	
Segmentectomy	7.4	
Lobectomy	80.0	
Bilobectomy	2.3	
Pneumonectomy	2.3	
Missing (n)	0	
Length of hospital stay (d)		7.88 (5.35)
2-5	33.1	
6-10	48.0	
11-15	13.7	
≥16	5.1	
Missing (n)	0	
No. surgical complications*		0.47 (0.73)
0	65.1	
1	25.1	
2	7.4	
3	2.3	
Missing (n)	0	
Current smoking status		
Current smoker	5.8	
Former smoker	79.8	
Never smoker	14.5	
Missing (n)	2	
Current weight status		25.85 (4.45)
Normal weight (BMI <25 kg/m^2)	45.9	
Overweight (BMI 25-29.9 kg/m^2)	38.2	
Obese (BMI ≥30 kg/m^2)	15.9	
Missing (n)	5	
No. current comorbid medical conditions †		2.47 (1.64)
0	10.4	
1	19.1	
2	27.2	
3	16.8	
4	15.6	
≥5	11.0	
Missing (n)	2	

Abbreviations: FEV1 = forced expiratory volume in the first second; BMI = body mass index.

*The most common surgical complications were atrial fibrillation (14.9%), prolonged air leak (6.3%), pneumonitis (5.7%), and pneumothorax (4.0%).

† The most prevalent comorbidities were having a cataract (39.9%), a prior cancer other than lung cancer (32.4%), osteoarthritis (31.8%), chronic obstructive pulmonary disease (24.9%), osteoporosis (20.8%), asthma (20.8%), and heart disease (13.3%).

the current time to 1 in 4 during the post-treatment and pre-diagnosis periods. Just over 1 in 4 participants met physical activity guidelines during the pre-diagnosis period. This rate significantly decreased to ~1 in 8 participants for the post-treatment period and significantly increased back to just over 1 in 4 participants for the current time.

Differences in Prevalence of Physical Activity across Time Points According to Demographic and Medical Factors. There were no statistically significant differences in the prevalence of physical activity across the three time points for any of the activity measures for the following variables: gender, age, pathologic stage, time since treatment, type of surgical resection, or current smoking status. Table 4 summarizes the variables for which differences were identified in one or more physical activity measures across the three time points. Individuals with fewer comorbid medical conditions increased their engagement in light intensity activities during the post-treatment period, whereas those with more comorbidities decreased such activities after treatment. Individuals with better preoperative pulmonary function (higher FEV1 % predicted) decreased their level of strenuous activities during the post-treatment period. Examination of absolute levels of strenuous activity indicated that those with worse pulmonary function were not engaging in such activities before diagnosis and thus a lack of post-treatment change in their strenuous activities is not surprising.

From the post-treatment period to the current time, individuals with a shorter post-resection hospital stay or fewer surgical complications increased their engagement in strenuous activities, whereas those with a longer hospital stay or more complications did not. For the post-treatment period, individuals having worse preoperative pulmonary function or reporting more comorbid medical conditions were more likely to have become sedentary than individuals with better pulmonary function and those with fewer comorbidities. Comparing the current time with the post-treatment period, individuals who were normal weight were less likely to have become sedentary, but there were no differences for overweight or obese individuals.

Patterns of Physical Activity across the Time Points. The pattern of participants' physical activity in terms of meeting or not meeting physical activity guidelines across the three time points is shown in Table 5. Classification labels for the physical activity patterns were drawn from prior research (28, 29). Almost two-thirds of participants did not meet physical activity guidelines for any of the time points and were denoted as nonexercisers. Almost all of the remaining participants fell equally into one of four activity patterns: met guidelines at all three time points (maintainers), did not meet guidelines during the pre-diagnosis or post-treatment periods but currently met guidelines (adopters), met guidelines during the pre-diagnosis and current time periods but did not meet guidelines during the post-treatment period (temporary relapsers), and met guidelines during the pre-diagnosis period but not during the post-treatment period or currently (permanent relapsers).

Among individuals who were currently sedentary, 62.9% were sedentary and 8.6% met activity guidelines

Table 3. Lung cancer survivors' physical activity during the 6 months before diagnosis, during the 6 months after completing treatment, and at the current time

	Pre-diagnosis weekly physical activity, mean (SD) or %	Post-treatment weekly physical activity, mean (SD) or %	Current weekly physical activity, mean (SD) or %	Comparison between time points		
				Pre-diagnosis vs post-treatment *P*	Pre-diagnosis vs current *P*	Post-treatment vs current *P*
Minutes of light activity	77.8 (119.9)	82.6 (132.3)	83.4 (149.7)	0.647	0.597	0.933
Minutes of moderate activity	73.2 (123.2)	29.2 (64.0)	59.8 (98.1)	**0.001**	0.155	**0.001**
Minutes of strenuous activity	24.5 (89.3)	8.1 (50.3)	17.9 (65.1)	**0.004**	0.179	**0.001**
% Sedentary*	24.0	25.1	20.0	0.773	0.223	0.150
% Meeting physical activity guidelines†	26.4	12.0	27.4	**0.001**	0.828	**0.001**

NOTE: Due to missing data, the sample size varies from $n = 172$ to $n = 175$. *P* values < 0.05 are denoted in bold.
*Defined as engaging in no light, moderate, or strenuous intensity activity.
†Defined as engaging in at least 150 min/wk of at least moderate intensity activity or at least 60 min/wk of vigorous intensity activity.

before diagnosis and 57.1% were sedentary and 2.9% met activity guidelines during the post-treatment period. Among individuals who currently met activity guidelines, 6.4% were sedentary and 66.0% met activity guidelines before diagnosis and 16.7% were sedentary and 35.4% met activity guidelines during the post-treatment period.

Differences in QOL According to Current Physical Activity Status. Table 6 shows the results of analyses examining differences in QOL according to participants' current physical activity status. We first describe the results from the unadjusted analyses. With regard to the SF-36 subscales, compared with less active individuals, those who met physical activity guidelines reported better QOL in terms of physical functioning, role limitations due to physical problems, general health perceptions, and vitality. There were no differences in QOL according to participants' current physical activity

Table 4. Summary of statistically significant changes in lung cancer survivors' physical activity across the pre-diagnosis, post-treatment, and current time periods according to select medical characteristics

	Change* from pre-diagnosis to post-treatment	*P* for change within group	*P* for interaction (difference in change)	Change* from post-treatment to current time	*P* for change within group	*P* for interaction (difference in change)
Light physical activity						
≤2 Comorbid conditions	34.7	**0.025**	**0.001**	−12.4	0.281	0.111
>2 Comorbid conditions	−33.6	**0.007**		18.5	0.237	
Strenuous physical activity						
Preoperative FEV1 ≤80% predicted	1.8	0.289	**0.001**	3.4	0.215	0.054
Preoperative FEV1 >80% predicted	−23.4	**0.002**		12.5	**0.001**	
Postoperative hospital stay ≤10 d	−16.3	**0.006**	0.981	11.9	**0.001**	**0.003**
Postoperative hospital stay >10 d	−15.9	0.282		0.9	0.311	
≤1 Surgical complication	−17.9	**0.004**	**0.004**	10.9	**0.001**	**0.001**
>1 Surgical complication	0.0	1.000		0.0	1.000	
Sedentariness†						
Preoperative FEV1 ≤80% predicted	0.82	0.058	**0.028**	−1.09	**0.006**	**0.014**
Preoperative FEV1 >80% predicted	−0.27	0.274		0.05	0.842	
Normal weight	0.37	0.251		−0.64	**0.019**	
Overweight	−0.60	0.107	**0.049**‡	0.28	0.439	**0.043**‡
Obese	0.33	0.479	0.950‡	−0.52	0.315	0.836‡
≤2 Comorbid conditions	−0.56	**0.047**	**<0.001**	−0.06	0.835	0.251
>2 Comorbid conditions	1.05	**0.002**		−0.53	0.069	

Abbreviation: FEV1 = forced expiratory volume in the first second.
NOTE: *P* values < 0.05 are denoted in bold.
*For light activity and strenuous physical activity, change scores represent regression estimates in minutes of activity per week, with positive scores denoting an increase in activity and negative scores a decrease in activity. For sedentariness, change scores are log odds ratios, with positive scores denoting a greater likelihood of becoming sedentary and negative scores denoting a lower likelihood of becoming sedentary.
† Sedentary defined as engaging in no light, moderate, or strenuous intensity activity.
‡ For comparison with normal weight individuals.

status for the SF-36 subscales for bodily pain, social functioning, mental health, and role limitations due to emotional problems. Individuals who met physical activity guidelines reported significantly less dyspnea than sedentary individuals. Additionally, those who met activity guidelines reported a significantly lower level of fatigue than individuals who engaged in low activity. There was no difference in anxiety symptoms according to physical activity status, but individuals meeting activity guidelines reported significantly fewer depression symptoms than sedentary individuals and those who engaged in low activity. The results of the adjusted analyses were largely consistent with those from the unadjusted analyses, indicating that differences in QOL according to physical activity status were not fully explained by potential confounding demographic or medical variables. Of note, all of the statistically significant differences in QOL between sedentary individuals and those who met activity guidelines in the unadjusted analyses were also significant in the adjusted analyses.

Discussion

Consistent with our expectations, lung cancer survivors reported engaging in fewer minutes of moderate and strenuous intensity activity during the early post-treatment period than before diagnosis and at the current time. This is likely attributable to the typically high prevalence of acute post-treatment symptoms such as pain, dyspnea, and fatigue (3). It was encouraging, however, that survivors' current level of moderate and strenuous intensity activities did not differ from levels reported for the pre-diagnosis period. Individuals with a shorter postoperative hospital stay or fewer surgical complications were more likely to increase their engagement in strenuous activities from the post-treatment period to the current time. This may be due to these individuals having better physical functioning or higher exercise capacity than individuals experiencing a longer hospital stay or more surgical complications, although future empirical research is needed to examine this issue.

Table 5. Longitudinal patterns of lung cancer survivors' physical activity across the 6 months before diagnosis, during the 6 months after completing treatment, and at the current time

Physical activity pattern	Pre-diagnosis	Post-treatment	Current	%
Maintainers	Active	Active	Active	8.7
Adopters	Inactive	Inactive	Active	8.1
Temporary relapsers	Active	Inactive	Active	9.3
Permanent relapsers	Active	Inactive	Inactive	8.1
Nonexercisers	Inactive	Inactive	Inactive	62.2
Other				3.5

NOTE: Active = meet physical activity guidelines (engage in at least 150 min/wk of at least moderate intensity activity or at least 60 min/wk of vigorous intensity activity); inactive = do not meet physical activity guidelines. n = 172.

Across the full sample, participants' reported engagement in light intensity activities and the percentage of individuals who were sedentary did not differ for the three cancer trajectory time points. However, individuals with more comorbid medical conditions reported a lower prevalence of light intensity activities and were more likely to become sedentary during the post-treatment period. Additionally, individuals with poorer preoperative pulmonary function were more likely to be sedentary during the post-treatment period. This suggests that individuals with more comorbidities or poorer preoperative pulmonary function may be especially in need of post-treatment rehabilitative support and assistance with regard to regaining activity levels.

As anticipated, the percentage of lung cancer survivors who engaged in sufficient activity to meet activity guidelines was lower during the post-treatment period compared with before diagnosis and at the current time. Just under two-thirds of participants did not meet guidelines at any of the three time points. Fewer than 1 in 10 participants met activity guidelines at all three time points. Further assessment of participants' activity status across the three time points indicated a large degree of consistency between individuals' current activity status and their activity status before diagnosis. These results suggest that after the acute post-treatment period, in which engagement in moderate and strenuous activities is uniformly low, most lung cancer survivors resume the level of physical activity (or inactivity) that they engaged in before their lung cancer diagnosis. Approximately 1 in 4 (27.4%) participants currently met physical activity guidelines, which is consistent with evidence that activity guidelines are met by 30.4% of U.S. adults ages 45 to 64 years, 27.0% of those ages 65 to 74 years, and 16.8% of those ages ≥75 years (30).

Individuals who currently met physical activity guidelines reported a higher QOL in several domains compared with less active individuals. In line with the results of several studies in other cancer survivor populations (26, 31, 32) as well as studies in the general adult population (33), there was greater evidence that activity was associated with physical as opposed to mental or emotional QOL domains. However, individuals meeting activity guidelines reported fewer depressive symptoms, suggesting the importance of examining mood as a potential barrier for, or benefit of, physical activity among lung cancer survivors. Across the QOL measures for which statistically significant differences were observed, the magnitude of QOL differences (e.g., in the unadjusted analyses, effect sizes from d = 0.40 to d = 0.80 comparing sedentary individuals and those who met activity guidelines) are suggestive of clinically meaningful differences (34). Overall, combined with the known QOL benefits of physical activity for other cancer survivor populations (7-9), the current study results suggest that interventions that successfully promote lung cancer survivors' engagement in physical activity may increase their QOL in several domains.

Study Strengths and Limitations. Strengths of the study include no indication of differences in available demographic and medical factors between study

Table 6. Differences in lung cancer survivors' QOL according to current physical activity status

QOL measure*	Full sample (n = 175), mean (SD)	Current physical activity status †			Comparison between groups		
		Sedentary (n = 35; 20.0%), mean (SD)	Low activity (n = 92; 52.6%), mean (SD)	Meet guidelines (n = 48; 27.4%), mean (SD)	Sedentary vs low activity P	Sedentary vs meet guidelines P	Low activity vs meet guidelines P
Physical functioning ‡	45.5 (9.6)	41.9 (11.0)	44.6 (9.5)	49.6 (7.2)	0.204	**<0.001**	**0.001**
Adjusted analysis					**0.024**	**<0.001**	0.110
Role limitations, physical problems§	45.9 (11.3)	44.1 (13.0)	43.9 (11.5)	51.0 (7.9)	0.931	**0.006**	**<0.001**
Adjusted analysis					0.741	**0.021**	**0.019**
Bodily pain	48.4 (11.3)	46.2 (12.8)	48.0 (10.7)	51.0 (11.1)	0.470	0.077	0.127
Adjusted analysis					0.454	0.298	0.665
General health perceptions‖	48.4 (9.9)	47.8 (9.8)	46.8 (10.2)	51.8 (8.5)	0.612	0.053	**0.003**
Adjusted analysis					0.886	0.454	0.302
Vitality§	51.9 (9.1)	48.1 (10.6)	52.2 (8.6)	54.3 (8.1)	**0.042**	**0.004**	0.149
Adjusted analysis					**0.001**	**0.007**	0.842
Social functioning	48.7 (11.5)	48.0 (12.8)	47.9 (12.0)	50.9 (9.0)	0.973	0.239	0.094
Adjusted analysis					0.407	0.513	0.903
Mental health	50.3 (9.5)	48.6 (9.9)	50.5 (9.7)	51.3 (8.7)	0.329	0.186	0.600
Adjusted analysis					0.126	0.270	0.613
Role limitations, emotional problems	49.8 (9.9)	50.1 (9.7)	48.8 (11.0)	51.5 (7.6)	0.502	0.477	0.087
Adjusted analysis					0.884	0.623	0.389
Dyspnea‖	8.5 (2.9)	7.5 (3.1)	8.5 (2.9)	9.4 (2.6)	0.092	**0.003**	0.064
Adjusted analysis					**0.025**	**0.012**	0.547
Fatigue‖	2.3 (2.2)	2.5 (2.5)	2.6 (2.2)	1.6 (1.8)	0.899	0.071	**0.007**
Adjusted analysis					0.712	0.157	0.197
Anxiety symptoms	4.8 (3.7)	5.2 (4.0)	4.8 (3.9)	4.5 (3.1)	0.615	0.384	0.609
Adjusted analysis					0.255	0.636	0.394
Depression symptoms‖	3.2 (3.1)	4.3 (3.8)	3.3 (2.9)	2.3 (2.6)	0.192	**0.009**	**0.035**
Adjusted analysis					0.058	**0.033**	0.622

NOTE: Each adjusted analysis controls for all of the demographic and medical variables shown in Tables 1 and 2. P values < 0.05 are denoted in bold.
*For each SF-36 subscale (physical functioning, role limitations due to physical problems, bodily pain, general health perceptions, vitality, social functioning, mental health, and role limitations due to emotional problems), scores represent norm-based T scores (general population mean = 50, general population SD = 10), and a higher score represents better QOL. For the dyspnea measure, a higher score represents lower dyspnea (possible range, 0-12). For the measures of fatigue (possible range, 0-10), anxiety symptoms (possible range, 0-21), and depression symptoms (possible range, 0-21), a higher score represents a greater prevalence of symptoms.
† Sedentary = engage in no light, moderate, or strenuous activity; low activity = engage in some light, moderate, or strenuous activity but below guideline recommended levels; meet guidelines = engage in at least 150 min/wk of at least moderate intensity activity or engage in at least 60 min/wk of vigorous intensity activity.
‡ $P < 0.001$, for the assciation between the QOL variable and current physical activity status.
§ $P < 0.01$, for the association between the QOL variable and current physical activity status.
‖ $P < 0.05$, for the association between the QOL variable and current physical activity status.

participants and decliners, a response rate (63.6%) that compares favorably with response rates from similar prior studies (e.g., refs. 25-27, 32, 35, 36), availability of data regarding key pre-resection and post-resection medical factors, and examination of the associations between physical activity and multiple QOL domains. Several limitations to the study should be noted. The cross-sectional research design prohibits examination of the causal direction of associations between physical activity and QOL. Physical activity for the pre-diagnosis and post-treatment periods was measured retrospectively, raising issues of potential recall inaccuracy. Prior studies have documented acceptable reliability and validity of self-reported assessments of physical activity over diverse historical periods, including up to 10 years and beyond (e.g., refs. 37-40), but no prior research has examined this issue in survivors of lung cancer. Lynch et al. (41) examined the test-retest reliability of reported pre-diagnosis physical activity among colorectal cancer survivors. The intraclass correlation coefficients for moderate intensity physical activity and activity categories (sedentary, low activity, and meet activity guidelines) were 0.77 (95% confidence interval, 0.68-0.84) and 0.62 (95% confidence interval, 0.48-0.76), respectively, and the overall reliability of the measure was comparable with that in a population-based sample of adults. However, future research is needed to determine the extent to which the reliability and validity of retrospective physical activity assessments may vary across survivors of varying cancers and according to survivors' demographic and medical characteristics (41). Although physical activity was assessed with a widely used, validated self-report measure, future research would benefit from the addition of objective activity measures. The study participants were mostly well educated and there was limited variability with regard to their race/ethnicity. Thus, the study results may not be generalizable to lung cancer survivor populations with other demographic characteristics.

Conclusions. There is a lack of research regarding the prevalence, patterns, and QOL correlates of physical activity in lung cancer survivors. The current study examined these key issues and fills an important knowledge gap in lung cancer survivorship research,

which as a whole is underrepresented within the burgeoning survivorship literature (3). Results suggest that physical activity among lung cancer survivors is particularly low during the early post-treatment period. Current engagement in physical activity is associated with better QOL in several domains. However, the vast majority of lung cancer survivors do not currently meet physical activity guidelines and may benefit from interventions to promote engagement in regular physical activities. With the developing formulation of long-term follow-up care for survivors of lung and other cancers, the current findings suggest that oncologists have an opportunity to recommend increased physical activity as a means of promoting post-treatment QOL. There is a need to develop and test physical activity interventions designed specifically for survivors of early-stage lung cancer. Such interventions should take into account these individuals' tendency to engage in activities of light or moderate intensity as well as their usual older age, frequent comorbid medical conditions, and common physical and QOL impairments. These interventions might also represent a core component of broader pulmonary rehabilitation programs for individuals with lung cancer. In light of documented benefits of such programs with regard to QOL, symptom control, and exercise capacity for individuals with lung diseases such as chronic obstructive pulmonary disease (42), there is reason for optimism for their utility for lung cancer survivors.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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References

1. American Cancer Society. Cancer facts and figures 2008. Atlanta: American Cancer Society; 2008.
2. Ries LAG, Melbert D, Krapcho M, et al., editors. SEER cancer statistics review, 1975-2005. Bethesda (MD): National Cancer Institute. Available from: http://seer.cancer.gov/csr/1975_2005.
3. Sarna L, Grannis FW, Jr., Coscarelli A. Physical and psychosocial issues in lung cancer survivors. In: Ganz PA, ed. Cancer survivorship: today and tomorrow. New York: Springer; 2007. p. 157–76.
4. Sugimura H, Yang P. Long-term survivorship in lung cancer: a review. Chest 2006;129:1088–97.
5. Samet JM, Wiggins CL, Humble CG, Pathak DR. Cigarette smoking and lung cancer in New Mexico. Am Rev Respir Dis 1988;137:1110–3.
6. Ogle KS, Swanson GM, Woods N, Azzouz F. Cancer and comorbidity: redefining chronic diseases. Cancer 2000;88:653–63.
7. Conn VS, Hafdahl AR, Porock DC, McDaniel R, Nielsen PJ. A meta-analysis of exercise interventions among people treated for cancer. Support Care Cancer 2006;14:699–712.
8. Demark-Wahnefried W, Jones LW. Promoting a healthy lifestyle among cancer survivors. Hematol Oncol Clin North Am 2008;22:319–42.
9. Schmitz KH, Holtzman J, Courneya KS, Masse LC, Duval S, Kane R. Controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. Cancer Epidemiol Biomarkers Prev 2005;14:1588–95.
10. Weinstein H, Bates AT, Spaltro BE, Thaler HT, Steingart RM. Influence of preoperative exercise capacity on length of stay after thoracic cancer surgery. Ann Thorac Surg 2007;84:197–202.
11. Bobbio A, Chetta A, Ampollini L, et al. Preoperative pulmonary rehabilitation in patients undergoing lung resection for non-small cell lung cancer. Eur J Cardiothorac Surg 2008;33:95–8.
12. Cesario A, Ferri L, Galetta D, et al. Pre-operative pulmonary rehabilitation and surgery for lung cancer. Lung Cancer 2007;57:118–9.
13. Jones LW, Peddle CJ, Eves ND, et al. Effects of presurgical exercise training on cardiorespiratory fitness among patients undergoing thoracic surgery for malignant lung lesions. Cancer 2007;110:590–8.
14. Cesario A, Ferri L, Galetta D, et al. Post-operative respiratory rehabilitation after lung resection for non-small cell lung cancer. Lung Cancer 2007;57:175–80.
15. Spruit MA, Janssen PP, Willemsen SC, Hochstenbag MM, Wouters EF. Exercise capacity before and after an 8-week multidisciplinary inpatient rehabilitation program in lung cancer patients: a pilot study. Lung Cancer 2006;52:257–60.
16. Clark MM, Novotny PJ, Patten CA, et al. Motivational readiness for physical activity and quality of life in long-term lung cancer survivors. Lung Cancer 2008;61:117–22.
17. Buist AS, Connett JE, Miller RD, Kanner RE, Owens GR, Voelker HT. Chronic Obstructive Pulmonary Disease Early Intervention Trial (Lung Health Study): baseline characteristics of randomized participants. Chest 1993;103:1863–72.
18. Ware JE, Kosinski M, Dewey JE. How to score version two of the SF-36 health survey. Lincoln (RI): QualityMetric; 2000.
19. Mahler DA, Weinberg DH, Wells CK, Feinstein AR. The measurement of dyspnea. Contents, interobserver agreement, and physiologic correlates of two new clinical indexes. Chest 1984;85:751–8.
20. Mendoza TR, Wang XS, Cleeland CS, et al. The rapid assessment of fatigue severity in cancer patients: use of the Brief Fatigue Inventory. Cancer 1999;85:1186–96.
21. Zigmond AS, Snaith RP. The Hospital Anxiety and Depression Scale. Acta Psychiatr Scand 1983;67:361–70.
22. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. Can J Appl Sport Sci 1985;10:141–6.
23. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Circulation 2007;116:1081–93.
24. Sallis JF, Saelens BE. Assessment of physical activity by self-report: status, limitations, and future directions. Res Q Exerc Sport 2000;71:S1–14.
25. Jones LW, Guill B, Keir ST, et al. Patterns of exercise across the cancer trajectory in brain tumor patients. Cancer 2006;106:2224–32.
26. Karvinen KH, Courneya KS, North S, Venner P. Associations between exercise and quality of life in bladder cancer survivors: a population-based study. Cancer Epidemiol Biomarkers Prev 2007;16:984–90.
27. Stevinson C, Faught W, Steed H, et al. Associations between physical activity and quality of life in ovarian cancer survivors. Gynecol Oncol 2007;106:244–50.
28. Courneya KS, Friedenreich CM. Relationship between exercise pattern across the cancer experience and current quality of life in colorectal cancer survivors. J Altern Complement Med 1997;3:215–26.
29. Milne HM, Gordon S, Guilfoyle A, Wallman KE, Courneya KS. Association between physical activity and quality of life among Western Australian breast cancer survivors. Psychooncology 2007;16:1059–68.
30. Adams PF, Schoenborn CA. Health behaviors of adults: United States, 2002-2004. National Center for Health Statistics. Vital Health Stat 2006;10(230).
31. Courneya KS, Friedenreich CM, Sela RA, Quinney HA, Rhodes RE, Handman M. The Group Psychotherapy and Home-based Physical Exercise (Group-HOPE) trial in cancer survivors: physical fitness and quality of life outcomes. Psychooncology 2003;12:357–74.
32. Lynch BM, Cerin E, Owen N, Aitken JF. Associations of leisure-time physical activity with quality of life in a large, population-based sample of colorectal cancer survivors. Cancer Causes Control 2007;18:735–42.
33. Bize R, Johnson JA, Plotnikoff RC. Physical activity level and health-related quality of life in the general adult population: a systematic review. Prev Med 2007;45:401–15.
34. Samsa G, Edelman D, Rothman ML, Williams GR, Lipscomb J, Matchar D. Determining clinically important differences in health status measures: a general approach with illustration to the Health Utilities Index Mark II. Pharmacoeconomics 1999;15:141–55.

35. Jones LW, Courneya KS, Vallance JK, et al. Association between exercise and quality of life in multiple myeloma cancer survivors. Support Care Cancer 2004;12:780–8.
36. Vallance JK, Courneya KS, Jones LW, Reiman T. Differences in quality of life between non-Hodgkin's lymphoma survivors meeting and not meeting public health exercise guidelines. Psychooncology 2005;14:979–91.
37. Blair SN, Dowda M, Pate RR, et al. Reliability of long-term recall of participation in physical activity by middle-aged men and women. Am J Epidemiol 1991;133:266–75.
38. Bowles HR, FitzGerald SJ, Morrow JR, Jr., Jackson AW, Blair SN. Construct validity of self-reported historical physical activity. Am J Epidemiol 2004;160:279–86.
39. Chasan-Taber L, Erickson JB, McBride JW, Nasca PC, Chasan-Taber S, Freedson PS. Reproducibility of a self-administered lifetime physical activity questionnaire among female college alumnae. Am J Epidemiol 2002;155:282–9.
40. Orsini N, Bellocco R, Bottai M, Pagano M, Wolk A. Reproducibility of the past year and historical self-administered total physical activity questionnaire among older women. Eur J Epidemiol 2007;22:363–8.
41. Lynch BM, Owen N, Newman B, et al. Reliability of a measure of prediagnosis physical activity for cancer survivors. Med Sci Sports Exerc 2006;38:715–9.
42. Lacasse Y, Martin S, Lasserson TJ, Goldstein RS. Meta-analysis of respiratory rehabilitation in chronic obstructive pulmonary disease: a Cochrane systematic review. Eura Medicophys 2007;43:475–85.

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