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Article

Association of Leisure-Time Physical Activity With Health-Related Quality of Life Among US Lung Cancer Survivors

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Abstract

Background: Physical activity and exercise improve function, symptom control, and health-related quality of life (QoL) for many cancer survivors; however, the evidence is limited and inconsistent in lung cancer. We examined the relationship between leisure-time physical activity (LTPA) and health-related QoL in a national sample of US lung cancer survivors.
Methods: We conducted a cross-sectional study using the Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System. We defined LTPA as a self-report of engaging in any physical activity or exercise such as running, calisthenics, golf, gardening, or walking for exercise in the past 30 days, health-related QoL as the number of days of having poor physical or mental health in the past 30 days, and general health status. We analyzed using multivariable logistic regressions with 95% confidence intervals (CIs). **Results:** Among 614 lung cancer survivors, 316 (51.5%) reported engaging in LTPA. The counts (and proportions) of participants who engaged in LTPA vs no LTPA were, respectively, 135 (42.7%) vs 63 (21.1%) for 0 days of poor physical health, 222 (70.3%) vs 174 (58.4%) for 0 days of poor mental health, and 158 (50.0%) vs 77 (25.8%) for good to excellent general health. In multivariable analyses, participating in LTPA was associated with odds ratios of 2.64 (95% CI = 1.76 to 3.96) and 1.43 (95% CI = 0.97 to 2.10) for 0 days of poor physical and mental health, respectively, and 2.61 (95% CI = 1.74 to 3.91) for good to excellent general health. **Conclusions:** Participating in LTPA was associated with improved health-related QoL. Interventions to promote LTPA and/or exercise-based rehabilitation may improve QoL among lung cancer survivors.

The US National Academy of Medicine emphasizes the fundamental importance of care in the posttreatment phase of cancer survivorship (1,2). Lung cancer is the second-most commonly diagnosed cancer and the number one cause of cancer death in men and women in the United States (3). Historically, most lung cancer cases were diagnosed at an advanced stage and treated with palliation. However, the landscape for lung cancer control is rapidly changing (4) thanks to advances in screening (5,-6), diagnostic modalities (7), technological improvements in surgery and radio-ablation (8,9), and targeted and immune checkpoint blockade therapies (10). As a result, lung cancer death rates are declining, by 5% annually for men and 4% for women from 2013 to 2017 (3). As the number of lung cancer survivors increase, addressing the specific survivorship and quality-of-life (QoL) challenges faced by this patient population becomes ever more important.

Lung cancer survivors have a high median age at diagnosis (71 years), lifetime tobacco exposure, and prevalence of comorbidities that include chronic obstructive pulmonary disease (COPD) and heart failure (11). In addition, curative-intent therapy of lung cancer traditionally uses a combination of surgical resection (8), radio-ablative therapy (9), and chemoradiation (12) and can lead to lung function loss (13), perioperative complications (14), and longer-term impairments in lung, heart, and other organ system function (15,16). Over time, these adverse effects accumulate, progress, and negatively impact health,

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thereby posing threats to the physical and psychosocial function, emotional well-being, independence, social interactions, and QoL of lung cancer survivors (17). As of 2019, more than 571 000 US lung cancer survivors need health services to manage these challenges (18).

Physical activity and exercise (PA/E) improve symptom control, physical function, and QoL for many cancer survivors (19). However, much of the evidence regarding the benefits of PA/E is derived from breast, colon, and prostate cancer survivors, who are younger, have less cigarette smoking exposure, have fewer comorbidities, and whose cancer organ sites do not play a direct role in exercise such as the lungs. Although previous studies have examined the relationship between PA/E and QoL among lung cancer survivors (20-27), limitations in sample size exist. To the best of our knowledge, no previous study has examined this relationship in a national US population. In this project, we analyzed the relationship between leisure-time PA (LTPA) and the health-related QoL of lung cancer survivors enrolled in the Centers for Disease Control and Prevention (CDC) Behavioral Risk Factor Surveillance System (BRFSS). We hypothesized that participation in LTPA was associated with better health-related QoL.

Methods

Study Overview

We conducted a cross-sectional study of people with lung cancer who participated in the CDC BRFSS. The BRFSS is a system of health-related telephone surveys that collect data from a national pool of US residents regarding their risk behaviors and chronic health conditions (28). Established in 1984, the BRFSS collects data in all 50 states, completes more than 400 000 adult interviews each year, and is the largest continuously conducted health survey system in the world. We used data from BRFSS surveys administered in years 2010, 2012, 2014, and 2016. We chose these years based on availability of cancer survivorship modules, which were administered every other year after their inaugural administrations in 2009 and up until 2016. We chose 2016 as the end year, as 2017 and 2018 data were not available at the start of our study. Twenty-one US states participated in the cancer survivorship modules in these selected years. The median response rates ranged from 45% to 55% and compared favorably with other US national surveys (29). The Colorado Multiple Institutional Review Board and VA Eastern Colorado Health Care System approved this study as not human subjects research (protocol #20–0302). We used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines to report findings (30).

In the BRFSS, cancer survivor status was ascertained by asking participants, “Has a doctor, nurse, or other health professional ever told you that you had (non-skin) types of cancer?” Participants who responded “yes” were asked follow-up questions related to cancer survivorship, including the number and type of cancer and ongoing cancer treatment. We identified lung cancer as the type of cancer reported by participants.

Exposure

We defined the primary exposure as self-reported LTPA. In the BRFSS, LTPA is assessed in the “exercise” rotating core section, which asks, “During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?” Responses are “yes” or “no.” We used these responses to indicate LTPA status as participating in “LTPA” or “No LTPA” in the previous 30 days. Frequency, intensity, time duration, and prediagnosis PA/E were not assessed. BRFSS physical activity questions are valid against accelerometry and reliable (31).

Outcomes

Our outcomes were health-related QoL, defined as physical, mental, and general health. In the BRFSS, physical (or mental) health is assessed as part of the Healthy Days—Health-Related Quality of Life core questions administered yearly, which asks, “Now think about your physical (or mental) health, which includes physical illness and injury (or stress, depression, and problems with emotions), for how many days during the past 30 days was your physical (or mental) health not good?” Responses are recorded as integers (0-30) indicating the number of days of poor physical (or mental) health. General health is assessed as part of the Health Status core question, which asks, “Would you say that in general your health is–,” with responses recorded as “Excellent,” “Very good,” “Good,” “Fair,” or “Poor.” All questions are valid measures of health-related QoL (32).

Covariates

We included covariates associated with PA/E (33) and/or health-related QoL and available in all survey years: age, sex, race, socioeconomic status, other health behaviors (smoking status, alcohol use), and clinical characteristics (body mass index), self-reported comorbidities (cardiovascular disease, history of other cancers), and year of survey administration. Cancer-specific information included active or ongoing treatment.

Statistical Analyses

We provided descriptive statistics and used χ^2 tests to compare characteristics between participants who participated in LTPA vs No LTPA. We used univariable and multivariable logistic regressions to analyze the relationship between LTPA and health-related QoL. We categorized physical and mental health as 0 or 1 to 30 days of poor health and general health as good to excellent or fair to poor, consistent with categories in the BRFSS (32). For multivariable analyses, we sequentially adjusted for covariates: age, sex, race (model 1); education, marital status, employment status (model 2); smoking status, body mass index, cardiovascular disease (model 3); current cancer treatment (model 4); and year of survey administration (model 5). Except for year of survey administration, all covariates were selected and grouped according to the respective models a priori, starting with variables in model 1, then stepwise addition of variable sets accordingly. We chose to sequentially and accumulatively adjust for covariates to assess the robustness of the estimated effects. We specified a priori the last model as inference. All covariates included were as in the descriptive statistics without modification.

In addition, we performed sensitivity analyses excluding participants who reported having active cancer treatment and exploratory analyses to examine the interaction between LTPA and smoking status on health-related QoL. All data were used as available without imputation, with missing data categorized as in the BRFSS, typically as “unknown/refused/missing.” We used odds ratios (ORs) and confidence intervals (CIs) as estimates of LTPA effects on health-related QoL. Statistical significance was defined as P less than .05 in 2-tailed tests. All analyses were performed using IBM SPSS Statistics 25.0 (Armonk, NY, USA).

Sample Size and Power Estimates

We included all eligible participants. We assumed 1:1 allocation of participants who engaged in LTPA and No LTPA and that 30.0% of participants would have impaired QoL (34). We estimated that, with 90% power (and .05) to detect at least a 2-fold increased odds [moderate effect size (35)] of better health-related QoL among those who engaged in LTPA compared with No LTPA, we would need at least 402 participants.

Results

Participants

We identified 614 lung cancer survivors with characteristics in Table 1. Most were older (aged 65 years or older), females, White, retired, and current or former smokers; 182 (29.6%) reported having more than 1 type of cancer, and 119 (19.4%) were actively receiving cancer treatment. Their mean (standard deviation) age at first cancer diagnosis was 61.9 (13.5) years. Compared with those with LTPA, a higher proportion of those with No LTPA were current smokers and receiving cancer treatment.

LTPA and Health-Related QoL Assessments

In all, 316 (51.5%) participants reported engaging in LTPA and 298 (48.5%) No LTPA in the past 30 days. Of the participants, 198 (32.2%) reported having 0 days of poor physical health and 396 (64.5%) 0 days of poor mental health. General health status was good to excellent in 235 (38.3%) participants.

Association Between LTPA and Health-Related QoL

Of those who reported participating in LTPA in the past 30 days, 135 (42.7%) had 0 days of poor physical health, compared with 63 (21.1%) in those with No LTPA; the respective counts (and proportions) for 0 days of poor mental health were 222 (70.3%) vs 174 (58.4%) and good to excellent general health 158 (50.0%) vs 77 (25.8%). Compared with participants who engaged in LTPA, approximately twice as many participants who engaged in No LTPA had 14-30 days of poor physical health (Table 2).

In bivariate analyses, engaging in LTPA, compared with No LTPA, was associated with 0 days of poor physical health (OR = 2.78, 95% CI = 1.95 to 3.97, $P < .001$), 0 days of poor mental health (OR = 1.68, 95% CI = 1.21 to 2.35, $P < .01$), and good to excellent general health (OR = 2.87, 95% CI = 2.04 to 4.03, $P < .001$). In multivariable analyses sequentially and accumulatively adjusting for demographics, socioeconomic status, clinical characteristics, current cancer treatment, and year of survey administration (Table 3), participating in LTPA was statistically significantly associated with higher odds of having 0 days of poor physical health (OR = 2.64, 95% CI = 1.76 to 3.96) and good to excellent general health (OR = 2.61, 95% CI = 1.74 to 3.91; model 5). Participating in LTPA was statistically significantly associated with higher odds of 0 days of poor mental health (OR = 1.49, 95% CI = 1.02 to 2.19; model 3) but not when adjusted for current cancer treatment (OR = 1.45, 95% CI = 0.99 to 2.14; model 4) and year of survey administration (OR = 1.43, 95% CI = 0.97 to 2.10; model 5).

In sensitivity analyses excluding participants actively receiving cancer treatment, the magnitudes (and statistical significance) of the estimated effects of LTPA on health-related QoL were similar to the main analyses (Table 4). In exploratory unadjusted analyses, there were statistically significant interactions between LTPA and smoking status on physical, mental, and general health. Participating in LTPA was statistically significantly associated with 0 days of poor physical health and good to excellent general health among current, former, and never smokers and 0 days of poor mental health among current and former smokers, but not among never smokers (Table 5).

Discussion

In this study using national data from the CDC BRFSS, we assessed and analyzed the relationship between LTPA and health-related QoL among US lung cancer survivors and found that approximately 50% reported engaging in LTPA in the previous 30 days. Participating in LTPA was associated with 2.64-fold higher odds of having 0 days of poor physical health and 2.61-fold higher odds of having good to excellent general health. These findings are important given the national nature of participants included and have implications toward lung cancer survivorship care.

Previous studies have examined the relationship between PA/E and QoL in lung cancer survivors (20-27). In the largest study to date, Sloan and colleagues (20) analyzed data from 1466 participants diagnosed and/or treated for lung cancer at the Mayo Clinic. Similar to our study, they found that self-report of being physically active was associated with better overall QoL and mental well-being. However, the authors did not perform multivariable analyses (20), limiting definitive conclusions. More recently, Hechtner and colleagues (21) performed a multicenter, cross-sectional study to identify factors associated with global QoL. Among 657 non-small cell lung cancer survivors from Germany, they found that the main factor associated with QoL was higher PA/E in multivariable analyses (21), highlighting the potential of PA/E to improve QoL.

In contrast, D'Silva and colleagues (22) examined the relationship between objectively measured sedentary time and moderate-to-vigorous intensity PA/E and the health status of 127 lung cancer survivors in Southern Alberta and found that sedentary time, but not moderate-to-vigorous PA/E, was associated with QoL in multivariable analyses. These results differ from our study, possibly because of differences in sample size, method of PA/E assessment, and/or definition of PA/E and health outcomes. For instance, whereas moderate-to-vigorous intensity PA/E was not associated with function or QoL, light-intensity PA/E was positively associated with the 50th and 75th percentiles of QoL.

The proportions of lung cancer survivors who did not engage in any PA/E and with poor or impaired health-related QoL are higher than those reported in previous studies (20-25,34). Although these differences may be related to variations in definitions of PA/E and health-related QoL, they may well reflect a more representative sample of lung cancer survivors with poorer overall health status.

Following cancer treatment, PA/E is recommended to mitigate long-term adverse effects of cancer treatment and

Table 1. Characteristics of US lung cancer survivors who completed the BRFSS surveys administered in years 2010, 2012, 2014, and 2016 (n = 614) by LTPA status

Participant characteristics	LTPA (n = 316), No. (%)	No LTPA (n = 298), No. (%)	P[b]
Age at time of survey, y			
<65	86 (27.2)	79 (26.5)	.49
≥65	230 (72.8)	217 (72.8)	
Male sex	127 (40.2)	102 (34.2)	.13
White race	267 (84.5)	263 (88.3)	.20
Education			.001
Did not graduate high school	38 (12.0)	53 (17.8)	
Graduated high school	101 (32.0)	127 (42.6)	
Attended college/technical school	101 (32.0)	73 (24.5)	
Graduated college/technical school	76 (24.1)	45 (15.1)	
Yearly income			.03
<$25 000	99 (31.3)	125 (41.9)	
$25 000 to <$50 000	101 (32.0)	83 (27.9)	
≥$50 000	71 (22.5)	48 (16.1)	
Don't know/refused/missing	45 (14.2)	42 (14.1)	
Marital status			.08
Married	148 (46.8)	117 (39.3)	
Divorced/widowed/separated	148 (46.8)	151 (50.7)	
Never married/refused/missing	20 (6.3)	30 (10.1)	
Employment status			.001
Employed/self-employed	53 (16.8)	33 (11.1)	
Retired	191 (60.4)	175 (58.7)	
Unable to work	39 (12.3)	72 (24.2)	
Unemployed/refused/missing	33 (10.4)	18 (6.0)	
Veteran status	76 (24.1)	62 (20.8)	.36
Health care coverage	308 (97.5)	292 (98.0)	.79
Last medical checkup			.001
Within past 1 year	272 (86.1)	261 (87.6)	
>1 year ago	42 (13.3)	23 (7.7)	
Never/don't know/refused/missing	2 (0.6)	14 (4.7)	
Smoking status			<.001
Current	48 (15.2)	84 (28.2)	
Former	215 (68.0)	169 (56.7)	
Never	52 (16.5)	41 (13.8)	
Don't know/refused/missing	1 (0.0)	4 (1.3)	
Overweight or obese	183 (57.9)	176 (59.1)	.07
Heavy alcohol use	19 (6.0)	23 (7.7)	.33
CAD	46 (14.6)	55 (18.5)	.32
CVA	30 (9.5)	39 (13.1)	.14
Previous cancer	96 (30.4)	86 (28.9)	.72
Current cancer treatment[a]	57 (18.0)	62 (20.8)	.048

[a]Data available in 606 participants. BRFSS = Behavioral Risk Factor Surveillance System; CAD = coronary artery disease; CVA = cerebrovascular disease; LTPA = leisure-time physical activity.
[b]Derived from χ^2 tests.

to promote and maintain health in survivorship care plans (36-38). However, the evidence of benefit is limited and inconsistent among lung cancer survivors (39). Recent systematic reviews suggest that exercise training improves exercise capacity (40,41). However, the benefits of exercise training on the symptom burden, function, and QoL are inconclusive (40,41). Moreover, traditional exercise training focuses on moderate-to-vigorous intensity PA/E, which can be challenging for patients who are older and have substantial physical and psychosocial barriers, high frailty, comorbidity burden, more advanced disease, and compromised lung function because of underlying COPD and/or prior lung resectional surgery (15,42,43). Recently, increasing light-intensity PA/E and reducing sedentary behavior are also recognized as important (44) and represent opportunities for further studies.

For wider uptake, PA/E interventions may also need to demonstrate benefits on health care cost, utilization, and/or survival. A recent model-based, cost-effectiveness analysis of a PA/E program for lung cancer survivors following curative-intent therapy suggested that it could be cost-effective (45). In addition, our exploratory analyses suggest that the relationship between LTPA and health-related QoL may be modified or influenced by smoking status. Another study of 332 680 US adults in the BRFSS suggested that behavioral interventions that combine smoking cessation and the promotion of PA/E may be particularly important (46). As well, little is known about the benefits of PA/E on comorbidity control among lung cancer survivors. Many patients have comorbid COPD, diabetes, and heart failure—major diseases characterized by high health care utilization and cost—for which exercise-based rehabilitation has established clinical roles. Also, the delivery of PA/E may

Table 2. Health-related quality of life by LTPA status among US lung cancer survivors who completed the BRFSS surveys administered in years 2010, 2012, 2014, and 2016 (n = 614)

Health-related quality of life	LTPA (n = 316), No. (%)	No LTPA (n = 298), No. (%)	P[a]
Physical health in past 30 days			<.001
0 days poor	135 (42.7)	63 (21.1)	
1-13 days poor	79 (25.0)	54 (18.1)	
14-30 days poor	88 (27.8)	173 (58.1)	
Don't know/not sure/missing	14 (4.4)	8 (2.7)	
Mental health in past 30 days			.01
0 days poor	222 (70.3)	174 (58.1)	
1-13 days poor	46 (14.6)	51 (17.1)	
14-30 days poor	42 (13.3)	63 (21.1)	
Don't know/not sure/missing	6 (1.9)	10 (3.4)	
General health status			<.001
Good to excellent	158 (50.0)	77 (25.8)	
Fair to poor	157 (49.7)	218 (73.2)	
Don't know/not sure/missing	1 (0.0)	3 (1.0)	

[a]Derived from χ^2 tests. BRFSS = Behavioral Risk Factor Surveillance System; LTPA = leisure-time physical activity.

Table 3. Adjusted odds ratios (95% confidence intervals) by leisure-time physical activity

Adjusted models[a]	Physical health (0 days poor), OR (95% CI)	Mental health (0 days poor), OR (95% CI)	General health (good-excellent), OR (95% CI)
Model 1: Demographics	2.83 (1.97 to 4.06)	1.68 (1.18 to 2.38)	2.99 (2.11 to 4.23)
Model 2: Socioeconomic status	2.66 (1.82 to 3.89)	1.56 (1.08 to 2.27)	2.62 (1.79 to 3.81)
Model 3: Clinical characteristics	2.66 (1.80 to 3.93)	1.49 (1.02 to 2.19)	2.57 (1.74 to 3.79)
Model 4: Current cancer treatment	2.63 (1.76 to 3.92)	1.45 (0.99 to 2.14)	2.56 (1.71 to 3.82)
Model 5[b]: Year of BRFSS survey	2.64 (1.76 to 3.96)	1.43 (0.97 to 2.10)	2.61 (1.74 to 3.91)

[a]Sequentially and accumulatively adjusting for covariates—model 1: age, sex, White race; model 2: education, marital status, employment status; model 3: smoking status, overweight-obese body mass index, coronary artery disease, cerebrovascular disease; model 4: current cancer treatment; model 5: year of survey administration. All covariates were categorized as in Table 1. BRFSS = Behavioral Risk Factor Surveillance System; CI = confidence interval; OR = odds ratio.
[b]Final model of inference.

Table 4. Sensitivity analyses excluding current cancer treatment—adjusted ORs (95% CIs) by leisure-time physical activity[a]

Adjusted models[b]	Physical health (0 days poor), OR (95% CI)	Mental health (0 days poor), OR (95% CI)	General health (good-excellent), OR (95% CI)
Model 1: Demographics	3.24 (2.19 to 4.80)	1.77 (1.19 to 2.63)	3.12 (2.13 to 4.57)
Model 2: Socioeconomic status	2.97 (1.97 to 4.50)	1.67 (1.09 to 2.57)	2.59 (1.71 to 3.91)
Model 3: Clinical characteristics	2.95 (1.93 to 4.52)	1.50 (0.96 to 2.34)	2.47 (1.61 to 3.78)
Model 4[c]: Year of BRFSS survey	2.97 (1.93 to 4.57)	1.45 (0.93 to 2.26)	2.53 (1.64 to 3.89)

[a]Excluded 119 participants on current cancer treatment. BRFSS = Behavioral Risk Factor Surveillance System; CI = confidence interval; OR = odds ratio.
[b]Sequentially and accumulatively adjusting for covariates—model 1: age, sex, White race; model 2: education, marital status, employment status; model 3: smoking status, overweight-obese body mass index, coronary artery disease, cerebrovascular disease; model 4: year of survey administration.
[c]Final model of inference.

Table 5. Exploratory analyses—unadjusted odds ratios (95% confidence intervals) of leisure-time physical activity by smoking status

LTPA and smoking status interaction[a]	Physical health (0 days poor), OR (95% CI)	Mental health (0 days poor), OR (95% CI)	General health (good-excellent), OR (95% CI)
Smoking status			
Current	3.14 (1.74 to 5.66)	2.09 (1.28 to 3.41)	2.30 (1.37 to 3.86)
Former	2.55 (1.67 to 3.89)	1.55 (1.05 to 2.28)	3.05 (2.01 to 4.61)
Never	3.05 (1.37 to 6.81)	1.07 (0.53 to 2.15)	2.66 (1.29 to 5.49)

[a]Statistically significant interactions between LTPA and smoking status on health-related quality of lif. CI = confidence interval; LTPA = leisure-time physical activity; OR = odds ratio.

need to include telehealth technology to overcome transportation, time, and other barriers associated with center-based rehabilitation (47). Telerehabilitation offers a promising strategy (48), especially in times of the global viral (eg, coronavirus disease 2019) pandemic that requires social distancing (49).

Our study has direct clinical implications (39,50). PA/E is an important component of health promotion that has benefits across various patient populations (44) and for which clinicians and health care systems have important roles (51). PA/E specialists and oncology clinicians can use a simplified Assess, Advise, and Refer approach to promote PA/E (52). As well, health care systems can implement PA/E vital sign assessments in outpatient clinic visits. For instance, Kaiser Permanente routinely assesses patients' exercise behaviors using 2 PA/E questions derived from the BRFSS (53), which result in improvements in exercise counseling, referrals, and clinical outcomes (54).

The strengths of our study include a sufficiently large, national sample from 21 US states (enhancing external validity); sensitivity analyses excluding participants undergoing active cancer treatment (strengthening internal validity); and predefined categories and definitions of LTPA and health-related QoL and a priori covariates (reducing chance and confounding bias).

Our study also has limitations. First, the cross-sectional design limits our ability to draw conclusions on the temporal relationships between LTPA and health-related QoL. It is possible that the relationship is not causal or that there is reverse causation—that is, those who feel better want to exercise more albeit this may not be mutually exclusive from exercise also inducing a better QoL. However, the sensitivity analyses that excluded patients who were on active cancer treatment did not change results, suggesting that poor health did not statistically significantly modify the relationship between LTPA and health-related QoL. In addition, a previous longitudinal study that examined the effects of PA/E on the physical and psychosocial symptoms of lung cancer survivors showed that patients who engaged in PA/E experienced statistically significantly better symptom control than did those with less active lifestyles (55). As well, recent randomized clinical trials among lung cancer survivors also suggest that improving walking and participating in home-based exercises can improve sleep quality (56), anxiety, and depressive symptoms (57), and possibly health-related QoL (58), especially with high-intensity training (59). Application of novel statistical methods, such as marginal structure modeling (which we were not able to apply because of absence of longitudinal assessments) (60) and/or prospective, randomized clinical trials with adequate statistical power, is needed to better elucidate the relationship between PA/E on health-related QoL. Second, although we adjusted for many important covariates, we did not have information on other types of PA/E (eg, occupational activity), prediagnosis PA/E, or other clinical variables such as time since first cancer diagnosis, lung function, COPD, musculoskeletal disease, or lung cancer–specific variables (stage, type of treatment received, and duration of time since lung cancer treatment completion), which may confound or modify the relationship between LTPA and health-related QoL. Third, despite previous validation studies, the self-reported nature of LTPA predisposes to reporting bias. Previous studies in other patient populations, including cancer survivors, have found that patients tend to overreport PA/E levels compared with accelerometry (61,62). It is likely that the prevalence of inactivity among lung cancer survivors is higher than 50%. Fourth, the absence of detailed information on LTPA (frequency, intensity, time duration, type) limits conclusions on the type and dose of LTPA most associated with a favorable health-related QoL. However, previous studies in other cancer survivors have demonstrated that higher intensity and longer duration of exercise training are needed to improve cancer-related health outcomes (19). Fifth, the descriptive and observational nature of our study provides no insight to the pathophysiological mechanisms relating LTPA and QoL or how to effectively improve LTPA in this patient population. Finally, despite a large sample of US lung cancer survivors, our findings may have limited generalizability because of a predominantly White, female, and younger-than-expected patient population.

In conclusion, in a large and national sample of US lung cancer survivors, we found that participating in LTPA was associated with better physical and general health-related QoL. Interventions to improve LTPA and/or exercise-based rehabilitation may improve health-related QoL among lung cancer survivors. Further prospective studies are needed to determine whether augmenting PA/E improves health-related QoL in lung cancer survivorship care

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Author contributions: DMH had full access to all data in the study and takes responsibility for the integrity of the data and accuracy of the data analysis. DMH and AVP contributed substantially to the study design, data analysis, and interpretation, writing, and final approval of the manuscript. DBB, JES-L, EDC, and RLK contributed substantially to the data interpretation, writing, and final approval of the manuscript.

Data Availability

The datasets used in this study were obtained from the US Centers for Disease Control and Prevention—Behavioral Risk Factor Surveillance System, available publicly at https://www.cdc.gov/brfss/annual_data/annual_data.htm.

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