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ORIGINAL ARTICLE

Promoting moderate-to-vigorous physical activities in patients with advanced lung cancer: preferences and social cognitive factors, and the mediating roles

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Abstract

Purpose The purpose of this study is to assess the prevalence and preferences of moderate-to-vigorous physical activities (MVPA) in patients with advanced lung cancer, explore the social cognitive factors that were associated with MVPA and interest in PA counseling and program, and examine the mediating role of social cognitive factors.

Methods This was a cross-sectional study. Questionnaires on PA levels, PA counseling and programming preferences, and social cognitive variables (social support and self-efficacy) were administered to 105 patients with advanced lung cancer. Linear regression model was used to explore the social cognitive factors associated with MVPA, and logistic regression model was used to explore the factors associated with interest in PA counseling and program. Mediation analysis was used to examine the mediating role of self-efficacy on social support and MVPA.

Results Merely 30.5% of patients met the recommended level of MVPA; however, the majority of patients (89.5%) were interested in PA program. Social support ($\beta = 0.60$; $p = 0.007$) and self-efficacy ($\beta = 1.06$; $p = 0.027$) were positively associated with MVPA. Specifically, self-efficacy mediated the relationship between social support and MVPA ($\beta = 0.63$, $p = 0.004$).

Conclusion The majority of the patients with advanced lung cancer did not meet the recommended level of MVPA; however, they are interested in receiving PA counseling and joining PA programs. Social support was key to promoting higher levels of MVPA, and the association was mediated by self-efficacy. The established mediating model provides insights into designing PA programs and targeting the mediating variable, self-efficacy, to enhance the level of MVPA.

Keyword Advanced lung cancer · Physical activity preferences · Survivorship · Health promotion · Social cognitive

Background

Lung cancer is the leading cause of cancer-related deaths in Hong Kong and worldwide [1], with the majority of patients diagnosed at either a locally advanced or metastatic stage [2]. Substantial evidence has shown that physical activity (PA) is safe and can improve or avoid a decline in exercise capacity and health-related quality of life in patients with lung cancer with or without treatment [3, 4], before or during the COVID-19 pandemic [5]. The updated evidence-based PA prescription for cancer survivors includes moderate intensity aerobic PA for at least 30 min for 3 times per week, and for at least 8–12 weeks [6]. The supplement of resistance training to aerobic training for at least 2 sets of 8–15 repetitions at the intensity of at least 60% of one repetition maximum, for at least 2 times per week is recommended [6]. A Cochrane Review revealed that moderate-to-vigorous physical activity (MVPA) yields greater health benefits than low-intensity PA among cancer survivors [7]. Studies also demonstrated that MVPA, but not light or mild intensity PA, was significantly associated with better quality of life and less cancer-related fatigue in patients with cancer [8, 9]. Among patients with advanced lung cancer, MVPA appeared to be safe and feasible [10].

Despite a growing awareness and health promotion, PA level remains extremely low in patients with inoperable lung cancer [11], and the majority of patients with lung cancer did not meet the recommended PA guideline [12].

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Understanding the factors that influence PA may serve as a guide for researchers and healthcare professionals to motivate patients to engage in PA. Since lung cancer patients experience a higher level of symptom burden than other cancer populations [13, 14], and since late-stage patients suffer from more severe symptoms than early stage cancer patients due to tumor progression and metastasis, late-stage lung cancer patients are prone to remain sedentary. To date, no studies have focused on patients with late-stage lung cancer. Hence, there is a need to explore the factors that may potentially promote MVPA, specifically within this population.

A recent meta-study revealed social support can facilitate PA motivation in cancer patients [15], and diverse studies provided evidence of the positive associations between social support and PA [16]. Social support is complex and multi-facet [17]. It can be expressed in various ways, consisting of instrumental support (physical assistance), emotional support (empathy), informational support (education, advisement), and material support (financial) [18]. Among patients with advanced cancer, perceived social support was associated with physical quality of life [19]. Perceived social support was crucial particularly among patients with advanced cancer; however, it is not easily modifiable by interventions in near term and is widely dependent on one's belief about social environment and social resources [20]. It would, hence, be beneficial to examine some easily modifiable factors that mediate the relationship between social support and PA. Social cognitive theories have been applied to understand individual's intentions to engage in PA and the actual performance of PA behavior. The theories incorporate individual cognitions and social resources to explain why some are motivated for health behaviors and some are not. The most crucial individual cognitions for developing PA intentions are likely to be individual's beliefs in being able to execute the behavior despite of difficulties and individual's anticipations of PA benefits (i.e. self-efficacy). Social resources that influence individual's intention and behavior are active social networks that give direct social support for engaging in PA, or establish social norms of being active. Bandura's social cognitive theory was one of the theories that posits individual and social resources are linked, and the interplay enables the initiation and maintenance of health behaviors such as PA [21].

To date, no studies investigated the associations between social cognitive factors and PA in patients with lung cancer or advanced cancer. The current study aims to (i) assess the prevalence and preferences of MVPA, (ii) explore the demographics, medical, and social cognitive factors that were associated with the level of MVPA, and interest in PA counseling and program, and (iii) examine the mediating role of self-efficacy on social support and MVPA in patients with advanced lung cancer.

Methods

Design

This study was a cross-sectional survey conducted in the oncology outpatient department of a public hospital in Hong Kong between October 2018 and October 2019. Ethics approval was obtained from the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB) (UW18-502).

Participants and settings

Convenience sampling was used to identify potentially eligible participants. Research assistants approached the potentially eligible participants at the outpatient clinic and explained the study purpose and details to them. Written informed consent was obtained from the participants before study commencement if they agreed, and participants were invited to complete a structured self-administered questionnaire. Research assistant checked and ensured all questionnaires were completed without missing data, and offered assistance if the participants encountered difficulties. Participants were eligible if they were (a) aged over 18 years, (b) diagnosed with stage IIIB/IV non-small cell lung cancer or extensive-stage small cell lung cancer; (c) able to understand and provide informed consent; (d) able to walk without assistive device, and (e) able to communicate in Cantonese, Mandarin, or English.

Sample size calculation

According to a previous study in inoperable lung cancer patients, approximately 27% of the patients met the physical activity guidelines as being physically active [11]. Using a margin of error of 9% and a 95% confidence level, the sample size needed for this study was 94.

Data collection

Study instrument

Physical activity level PA level was assessed using the Leisure Score Index (LSI) of the Godin Leisure Time Exercise Questionnaire (GLTEQ) [22]. The GLTEQ assesses the frequency of strenuous (with their heart beating rapidly), moderate (not exhausting), and mild (minimal effort) leisure time PA performed for at least 15 min in a typical 7-day period. The total LSI is calculated by weighting each frequency by its estimated intensity in metabolic equivalents (METs) and summing to obtain a total LSI score using the following

formula: (3 × mild) + (5 × moderate) + (9 × strenuous). In accordance with the physical guidelines by the ACSM [23], Godin et al. [24] classified PA as active (moderate-to-strenuous LSI ≥ 24) and insufficiently active (moderate-to-strenuous LSI ≤ 23). MVPA was a continuous variable presented by the moderate-to-strenuous LSI. In this study, participants were asked to record their PA frequency a week before. The GLTEQ is a valid and reliable measure of PA behavior and has a 1-month test–retest reliability of 0.62, concurrent validity coefficients of 0.32, and an accelerometer [25].

Physical activity preferences PA preferences were assessed by PA counseling and program preference questionnaires designed for cancer survivors by Denmark-Wahnefried et al. [26] and Jones and Corneya [27]. The questionnaire consists of two parts. The first part includes five questions that are used to assess PA counseling preferences, and the other part includes 14 questions used to assess PA preferences. The Chinese version of the questionnaire was validated and applied to Taiwanese patients with lung cancer [28].

Social support for physical activity PA social support levels were evaluated by "Perceived social support specific to health-related eating and PA behaviors" with 13 questions [29]. Each question is examined by a 5-point Likert scale ranging from 1 denoting "never" (received support) to 5 denoting "very often" (received support). The scale of social support reveals how much PA support participants received from their family, friends, and medical staff. A previous study regarding the psychosocial predictors for PA adjustment and maintenance of 205 healthy adults revealed good reliability and a high internal consistency of 0.91 to 0.92 [30]. The questionnaire was translated and used for Taiwanese patients with lung cancer [28].

Self-efficacy for physical activity A five-item self-efficacy measure, which is designed to evaluate the amount of self-confidence needed for a patient to maintain consistent PA in unfavorable situations, was adopted [31]. Items represent areas of negative affect, resisting relapse, and making time for PA. An 11-point scale is used to rate each item, with a 1 indicating "not at all confident" and an 11 indicating "very confident." This study of the psychosocial predictors for PA adjustment and maintenance of 205 healthy adults revealed good reliability and a high internal consistency of 0.86 [30]. The questionnaire was translated and validated for Taiwanese patients with lung cancer [28].

Sociodemographic characteristics Demographic and medical variables were assessed using self-report questionnaires. Demographic characteristics included age, sex, marital status, education, employment status, and BMI, whereas medical variables included time since diagnosis, cancer stage, and current treatment status. The Karnofsky Performance Status (KPS) score, which measures the performance of activities of daily living of the patients, was assessed by nurses.

Statistical analysis

Main analysis

Descriptive statistics were used to summarize the demographic and medical characteristics of the participants, as well as the participants' PA preferences. Variables were dichotomized based on clinically relevant cut off points or the nearest median splits. Specifically, age was dichotomized as < 65 or ≥ 65; body mass index was dichotomized as overweight (BMI ≥ 23) or normal (BMI < 23) according to the recommended criteria in Asian populations. Education was dichotomized as primary education or below, or secondary education and above. Years since diagnosis was dichotomized as 0–24 months, or more than 24 months. A multivariable linear regression was employed to explore the factors associated with MVPA. Factors such as age, sex, education, marital status, BMI, KPS, time since diagnosis, treatment status, social support, and self-efficacy were added to the model. The absence of multicollinearity was checked in the models. A multivariable logistic regression was performed to examine the association of each factor (demographic, medical, and social cognitive factors) with participants' interest in PA counseling and program.

Mediation analysis

Baron and Kenney's multistage regression approach [32] was adopted to examine the mediating effect of PA self-efficacy on the association between social support and MVPA. Demographic and medical variables that were significantly associated with MVPA were included as covariates in the three models. The following associations were examined using linear regressions and illustrated in Supplementary Fig. 1 (a) the association between social support and MVPA (path C); (b) the association between social support and PA self-efficacy (path A); (c) the association between PA self-efficacy and MVPA (path B); and (d) the association between social support and MVPA after adjusting PA self-efficacy (path C*).

Biased-corrected bootstrapping method with 5000 replications was performed to assess the mediating effect of PA self-efficacy with adjustment for sociodemographic and clinical factors using the PROCESS macro for SPSS [33]. The significance of the mediating model was indicated by 95% CI of the indirect effect of social support on MVPA through PA self-efficacy. An indirect effect was considered statistically

significant if the 95% CI did not contain zero. The ratio of the indirect effect to the total effect was used to quantify the effect size of the mediation model as an indication of the proportion of the total effect mediated by the mediator.

Sociodemographic and clinical factors, such as age, sex, marital status, education, BMI, KPS, time since diagnosis, and treatment modality were adjusted in the analyses to overcome the potential confounding effects. All statistical analyses were performed using IBM SPSS (version 26.0; IBM Corp., Armonk, NY). The PROCESS macro for SPSS was used to conduct the mediation analysis [34]. All statistical tests were two-sided, and the level of significance was set at 0.05.

Results

Characteristics of participants

A total of 105 patients with advanced lung cancer were recruited into the study with a response rate of 66.5%, that is, 158 potentially eligible patients were contacted. The major reasons for non-participation were the lack of interest in research and lack of time. Table 1 presents the characteristics of the study sample. Slightly more than half of the participants were female (58.1%) with a mean age of 61.69 ± 8.88 years. The majority of the participants attained secondary or higher education (80.0%) and were married or cohabiting (67.6%). Approximately 96.2% of the participants were receiving cancer treatment, of whom about half were receiving chemotherapy (51.5%). The mean time since diagnosis was 27.16 ± 26.24 months. The mean KPS was 86.57 ± 9.89. Most of them were not active smokers or drinkers.

Prevalence of physical activity

On average, the total LSI was 25.50 ± 19.43, and moderate-to-strenuous LSI was 18.50 ± 22.04. More than half (69.5%) of the participants scored < 24 in moderate-to-strenuous LSI, indicating that they did not meet the recommended level of PA. Almost half (47.9%) of the insufficiently active participants were completely sedentary and reported not having engaged in weekly MVPA.

Physical activity program and counseling preferences

The participants' preferences for PA counseling are shown in Table 2. The majority of the participants were willing or maybe willing (88.6%) to receive PA counseling, and the most preferred delivery channel was face-to-face counseling (67.6%). Majority of the participants preferred to receive counseling from an exercise specialist affiliated with a cancer center (42.9%), in cancer center (62.9%), and during treatment (57.1%).

Table 1 Characteristics of the study sample ($n = 105$)

Sociodemographic characteristics	Mean (SD)	*n* (%)
Age (years)	61.69 (8.88)	
Sex		
Male		44 (41.9%)
Female		61 (58.1%)
Education level		
Primary or below		21 (20.0%)
Secondary or above		84 (80.0%)
Body mass index (BMI)		
Normal (BMI < 23)		78 (74.3%)
Overweight (BMI ≥ 23)		27 (25.7%)
Karnofsky Performance Status	86.57 (9.89)	
Treatment status		
Receiving treatment		101 (96.2%)
Chemotherapy		52 (51.5%)
Non-chemotherapy		49 (48.5%)
Not receiving treatment		4 (3.8%)
Time since diagnosis	27.16 (26.24)	
Marital status		
Single/divorced/widowed		34 (32.4%)
Married/cohabiting		71 (67.6%)
Current smoker		
No		98 (93.3%)
Yes		7 (6.7%)
Current drinker		
No		93 (88.6%)
Yes		11 (10.5%)
Leisure score index (moderate-to-strenuous)		
Insufficiently active (< 24)		73 (69.5%)
Active (≥ 24)		32 (30.5%)
Moderate-to-vigorous physical activity	18.50 (22.04)	

BMI, body mass index; *SD*, standard deviation

The majority of the participants (89.5%) were interested in the PA program, and more than half (56.2%) felt they were able to participate in the program (Table 3). The most preferred company was a group of cancer or non-cancer survivors (56.2%), most preferred to perform PA at a community exercise center (43.8%), and in the morning (55.2%). Walking was the most preferred type of PA (49.5%), while most preferred low intensity PA (47.6%). The majority of participants preferred to start the PA program during treatment (50.5%), preferred variability in activities each time (60%), preferred flexibility in structure (56.2%), preferred to perform PA under supervision (82.9%), and preferred recreational activities (97.1%).

Table 2 Descriptive statistics for physical activity counseling preferences

Variable	*n* (%)
Would you prefer to receive physical activity counseling?	
Yes	43 (41.0%)
No	12 (11.4%)
Maybe	50 (47.6%)
Who would you prefer to receive physical activity counseling from?	
Oncologist	19 (18.1%)
Nurse	11 (10.5%)
Exercise specialist affiliated with a cancer center	45 (42.9%)
Exercise specialist affiliated with a community center	8 (7.6%)
A cancer patient/survivor	6 (5.7%)
Others	16 (15.2%)
When would you prefer to receive physical activity counseling?	
Before treatment	12 (11.4%)
During treatment	60 (57.1%)
Immediately after treatment	13 (12.4%)
3–6 months after treatment	18 (17.1%)
At least 1 year after treatment	2 (1.9%)
Where would you prefer to receive physical activity counseling?	
Cancer center	66 (62.9%)
Community center	25 (23.8%)
At home	14 (13.3%)
How would you prefer to receive physical activity counseling?	
Face to face	71 (67.6%)
By telephone	16 (15.2%)
Videotape	2 (1.9%)
Brochure/pamphlet	9 (8.6%)
Over the internet	7 (6.7%)
On audiotape	0

Factors associated with the level of moderate-to-vigorous physical activity

A linear regression demonstrated that social support from family and friends, and PA self-efficacy were significantly associated with MVPA, while age, sex, marital status, BMI, KPS, education level, treatment modalities (chemotherapy or non-chemotherapy), and time since diagnosis were not significantly associated with MVPA. Higher social support ($\beta = 0.60$; 95% CI = 0.17, 1.03; $p = 0.007$) and self-efficacy ($\beta = 1.06$; 95% CI = 0.12, 2.00; $p = 0.027$) were positively associated with higher MVPA levels (Table 4). The variance inflation factor for all factors was less than 2, indicating the absence of multicollinearity problems.

Factors associated with interest in physical activity counseling and program

As shown in Table 5, participants with secondary education or above (odds ratio [OR] = 22.09; 95% CI = 3.52, 138.56; $p = 0.001$) and those with greater social support (OR = 1.09; 95% CI = 1.02, 1.16; $p = 0.006$) were more willing to receive PA counseling. Participants with secondary education or above (OR = 5.85; 95% CI = 1.36, 25.22; $p = 0.018$), and had higher self-efficacy (OR = 1.19; 95% CI = 1.04, 1.37; $p = 0.011$) were more likely to be interested in participating in a PA program. Participants who were married (OR = 0.08; 95% CI = 0.02, 0.42; $p = 0.003$), and were diagnosed for more than 2 years (OR = 0.16; 95% CI = 0.05, 0.56; $p = 0.004$) were less likely to be interested in participating in a PA program.

Mediation models

Social support

Figure 1 depicts the results of the mediating effects of PA self-efficacy between social support and MVPA. A significant relationship between social support and MVPA was demonstrated ($\beta = 0.82$, $p = 0.001$). Social support was significantly correlated with PA self-efficacy ($\beta = 0.17$, $p = 0.0003$). After controlling

Table 3 Descriptive statistics for physical activity program preferences

Variable	*n* (%)
Would you be interested in a physical activity program?	
Yes	82 (78.1%)
No	11 (10.5%)
Maybe	12 (11.4%)
Are you able to participate in a physical activity program?	
Yes	59 (56.2%)
No	7 (6.7%)
Maybe	39 (37.1%)
Who would you prefer to exercise with?	
Alone	18 (17.1%)
With one to two cancer survivors	6 (5.7%)
With one to two non-cancer survivors	2 (1.9%)
With a group of cancer survivors	54 (51.4%)
With a group of non-cancer survivors	5 (4.8%)
No preference	20 (19.0%)
Where would you prefer to exercise?	
At home	19 (18.1%)
Community exercise center	46 (43.8%)
Outdoors	12 (11.4%)
No preference	28 (26.7%)
What time of day would you prefer to exercise?	
Morning	58 (55.2%)
Afternoon	14 (13.3%)
Evening	3 (2.9%)
No preference	30 (28.6%)
What type of physical activity would you prefer to do?	
Walking	52 (49.5%)
Dancing	6 (5.7%)
Swimming	6 (5.7%)
Cycling	5 (4.8%)
Jogging	9 (8.6%)
Ball games	3 (2.9%)
Qigong	11 (10.5%)
Gymnastics	5 (4.8%)
Others	7 (6.7%)
When would you prefer to start a physical activity program?	
Before treatment	21 (20.0%)
During treatment	53 (50.5%)
Immediately after treatment	16 (15.2%)
3–6 months after treatment	13 (12.4%)
At least 1 year after treatment	1 (1.0%)
What intensity would you prefer your physical activity program to be?	
Low	50 (47.6%)
Moderate	38 (36.2%)
High	0
No preference	17 (16.2%)
What type of physical activities would you like to perform?	
Same each time	42 (40.0%)
Different each time	63 (60.0%)
How would you prefer to perform these physical activities?	
Supervised	87 (82.9%)

Table 3 (continued)

Variable	*n* (%)
Unsupervised	18 (17.1%)
How would you prefer the structure of your physical activity program to be?	
Flexible	59 (56.2%)
Scheduled	46 (43.8%)
What type of activities would you prefer?	
Recreational	102 (97.1%)
Competitive	3 (2.9%)

Table 4 Factors associated with the level of moderate-to-vigorous physical activity

	Moderate-to-vigorous physical activity level	
	Beta (95% CI)	*p* value
Age		
65 or over vs. under 65[#]	−3.21 (−11.87, 5.46)	0.464
Gender		
Female vs. male[#]	4.61 (−3.71, 12.93)	0.274
Marital status		
Married vs. single[#]	0.81 (−8.52, 10.13)	0.864
Body mass index (BMI)		
Overweight (BMI ≥ 23) vs. normal weight (BMI < 23)[#]	0.89 (−8.32, 10.11)	0.848
Karnofsky Performance Status	0.40 (−0.01, 0.80)	0.055
Education level		
Secondary education and above vs. primary education or below[#]	1.00 (−9.48, 11.47)	0.850
Treatment modalities		
Chemotherapy vs. non-chemotherapy[#]	−3.46 (−11.43, 4.52)	0.392
Time since diagnosis		
> 24 vs. ≤ 24[#]	1.40 (−6.82, 9.62)	0.736
Social support	0.60 (0.17, 1.03)	0.007*
Self-efficacy	1.06 (0.12, 2.00)	0.027*

BMI, body mass index; *CI*, confidence interval

*$p < .05$

[#]Reference group

for PA self-efficacy, the direct effect between social support and MVPA was found to be statistically significant ($\beta = 0.63$, $p = 0.004$). Yet, the coefficients of the direct effect appeared smaller than those of the total effect ($\beta = 0.82$, $p = 0.001$), hence denoting the roles of PA self-efficacy as partially mediating the pathways between social support and MVPA.

The bootstrapping method showed that the 95% confidence intervals (corrected for bias) did not contain zero, supporting the partial mediation models. The effect size was 0.23, suggesting that the indirect effect accounted for 23% of the total effect between social support and MVPA respectively.

Discussion

This study is the first to investigate the social cognitive factors associated with, and mediators of MVPA in patients with advanced lung cancer. This study extends other research on PA prevalence and preferences of lung cancer patients by providing a more comprehensive assessment of PA prevalence, counseling, and program preferences, factors associated with and mediators of MVPA level in patients with advanced stage lung cancer, the stage when the majority of patients with lung cancer were first diagnosed at. In this study, only 30.5% of patients met the recommended level of MVPA, and social support and self-efficacy were found to be correlated with MVPA. In addition, self-efficacy mediated the relationship between social support and MVPA. This information can inform the development of future PA programs for patients with advanced lung cancer.

More than half of the participants did not meet the recommended level of MVPA, which is consistent with a recent study in cancer patients that the majority of them were insufficiently active with only 7% of them met the PA recommendations [35]. More strategies are needed to encourage cancer patients to be physically active, and it underscores the need to develop PA programs that would interest the particular patient population. To supplement previous research on the preferences of PA programs in patients with metastatic lung cancer [36], we explored the preferred PA program and PA counseling in detail. An effective counseling program can prompt changes in patients' PA behavior by increasing or maintaining higher PA levels, especially for those who are ready to be committed to improving their life through exercising or struggling to search for a suitable PA modality [37]. The majority of the participants preferred to receive face-to-face PA counseling from an exercise specialist affiliated with a cancer center during treatment, which differed from other studies of lung cancer patients in both Asian and non-Asian countries that showed a preference for receiving counseling from physicians [28, 38]. This reflects the clinical context in Hong Kong that physicians may not have sufficient time discussing PA with patients. This also highlights the need for cancer centers to launch PA counseling services, as well as the importance that exercise specialists should be equipped

Table 5 Factors associated with interest in PA counseling and program

	Interest in PA counseling		Interest in PA program	
	Odds ratio (95% CI)	*p* value	Odds ratio (95% CI)	*p* value
Age				
65 or over vs. under 65[#]	0.78 (0.27, 2.23)	0.641	0.58 (0.17, 1.95)	0.380
Gender				
Female vs. male[#]	1.80 (0.65, 4.96)	0.257	1.74 (0.55, 5.51)	0.345
Marital status				
Married vs. single[#]	1.41 (0.46, 4.28)	0.544	0.08 (0.02, 0.42)	0.003*
Body mass index (BMI)				
Overweight (BMI ≥ 23) vs. normal weight (BMI < 23)[#]	2.02 (0.64, 6.39)	0.232	1.37 (0.38, 4.98)	0.631
Karnofsky Performance Status	1.00 (0.95, 1.06)	0.966	1.01 (0.95, 1.06)	0.867
Education level				
Secondary education and above vs primary education or below[#]	22.09 (3.52, 138.56)	0.001*	5.85 (1.36, 25.22)	0.018*
Treatment modalities				
Chemotherapy vs. non- chemotherapy[#]	1.41 (0.53, 3.78)	0.494	0.73 (0.23, 2.31)	0.590
Time since diagnosis				
> 24 vs. ≤ 24[#]	0.68 (0.24, 1.87)	0.449	0.16 (0.05, 0.56)	0.004*
Social support	1.09 (1.02, 1.16)	0.006*	1.01 (0.95, 1.07)	0.775
Self-efficacy	1.07 (0.95, 1.21)	0.256	1.19 (1.04, 1.37)	0.011*

BMI, body mass index; *CI*, confidence interval; *PA*, physical activity

*$p < .05$

[#]Reference group

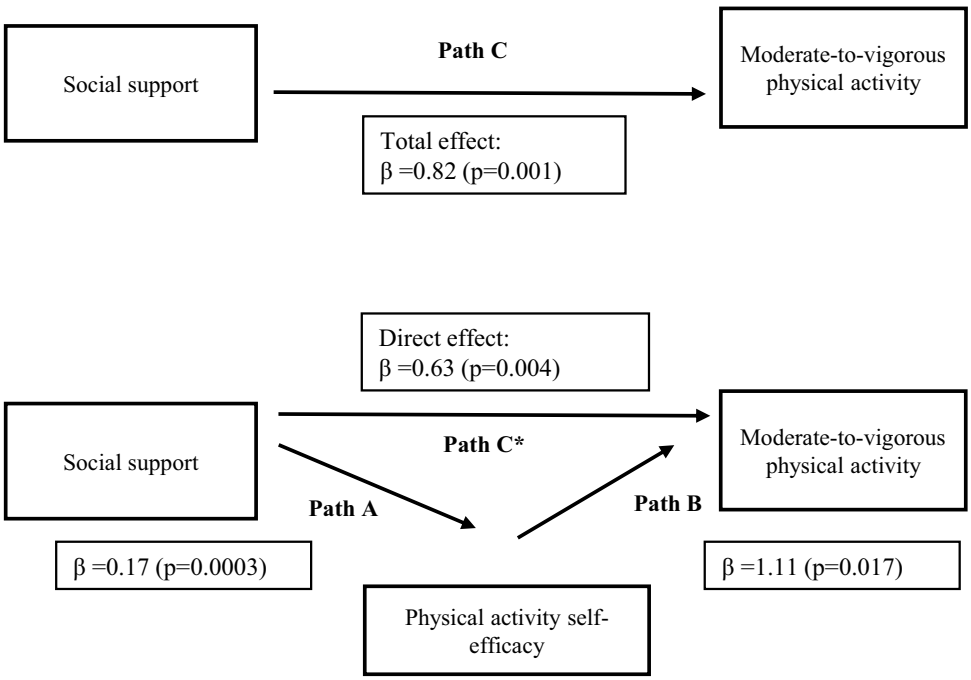

Fig. 1 Mediation model. Mediation model is significant (95% CI: 0.02, 0.43). Physical activity self-efficacy accounts for 23% of the mediation between social support from family and MVPA

with adequate knowledge of cancer, specifically knowledge and instruction on PA in this vulnerable population.

As in the findings from a systematic review of various cancer populations, the most preferred PA modality was walking [39]. Walking is a type of physical activity that is less demanding in terms of resources and equipment. Walking is also an activity in which the intensity can be controlled. Thus, it appears to be an alluring option among

PA types and can be incorporated as a major component of PA programs for cancer patients. Unlike lung or other cancer populations who prefer moderate-intensity PA [27, 28, 38, 40, 41], most patients in our study preferred low intensity PA, suggesting that patients with advanced lung cancer might be more susceptible to physical limitations and a heavier symptom burden than other cancer populations. This may as well reflect patients' fear of injury as reported in cancer patients with bone metastasis [42]. This highlights the importance of educating patients about PA safety and how to monitor their exercise intensity [43]. Future physical activity programs designed for advanced cancer patients can consider adopting low-intensity PA or starting with low-intensity PA and gradually increasing to moderate intensity, if tolerable, because moderate intensity PA appeared to be safe and acceptable in this population [44].

In addition, we found that participants with higher education level and social support were more willing to receive PA counseling, whereas participants who were single, diagnosed within 2 years, with higher education, and self-efficacy were more likely to be interested in a PA program. Hence, more strategies are needed to motivate individuals with lower education level, diagnosed for longer periods, with lower level of social support, and self-efficacy in order to adopt behavioral change.

Consistent with previous studies of early stage lung cancer and mixed advanced cancer populations [12, 45], our study found social cognitive variables to be significantly correlated with MVPA, underscoring the significance of social cognitive factors in this vulnerable population. In particular, this is the first study that found PA self-efficacy partially mediated the impact of social support on MVPA in adult cancer population. Our findings are supported by a conceptual framework that suggests self-efficacy could potentially moderate the effects of social support on PA [21]. An individual with higher self-efficacy benefits more from support, as they are more likely to translate support into PA. Study demonstrated that PA self-efficacy is an important factor for long-term PA adherence in older adults that can be effectively manipulated [46]. Future PA intervention can consider integrating self-efficacy building as a component to enhance MVPA level. Strategies of building self-efficacy could be diffusing sense of mastery and autonomy in PA, and developing enjoyable engagement.

As patients with advanced cancer were susceptible to higher symptom burden than early-stage cancer patients [47], greater family and peer social support tend to enhance their self-confidence in their ability to take part in MVPA despite physical and psychological side effects of cancer. The plausible explanation would be patients with higher level of social support are prone to having greater diversity of external supporting system, through which they can attain verbal encouragement, observing and modelling healthy lifestyle, and receiving help to cope with stress. These can promote the level of self-efficacy in cancer patients, and allow them to be readily engage in PA. In addition, regular engagement in PA may elicit positive feedback and support from family and friends, hence, reinforcing patients' self-efficacy and continuous PA engagement. Future research could as well explore the preferred ways of promoting self-efficacy in this population. This could be implemented strategies for building self-efficacy, involve patients' family and friends to engage in PA with them, arrange discussion on the previous positive PA experiences, or offer positive encouragement.

Strength and limitations

This study is the first to assess the detailed PA counseling, program preferences, and the mediational relations between social support and self-efficacy on MVPA in patients with advanced lung cancer. The findings allow for a specialized PA program design. Nonetheless, this study has several limitations. First, recruitment was performed in one cancer center, which might affect the generalizability of the results. Second, a fundamental selection bias may exist, as patients who were interested in exercising were more likely to participate. Third, the use of self-report measures of PA was subject to recall errors and subjective bias. Forth, the frequency of participants engaging in resistance training has not been assessed. Future studies should assess both aerobic and resistance training of the participants in order to be more comprehensive. Lastly, the cross-sectional design of this study makes it difficult to determine the causal relationship and the extent to which associations between measures reflect an influence of a measure on another over time in the mediation models [48].

Implications for practice

The findings of this study highlight that emphasis should be placed on patients' self-efficacy that plays a mediating role between social support and MVPA. As PA self-efficacy is a modifiable factor, it can be a promising target for promoting MVPA, especially among those with low social support. Strategies to promote self-efficacy include diffusing sense of mastery and autonomy in PA, and developing enjoyable engagement. As the majority of participants preferred to commence PA at a low intensity, future PA interventions can enhance patients' self-efficacy by commencing at an easily tolerable level, and gradually increase to a higher level, if tolerable. Furthermore, PA counseling and programming preference in patients with advanced lung cancer could aid health promotion in the development and implementation of PA programs. Providing face-to-face PA counseling can increase sedentary patients' interest in

PA. The optimal timing to start PA counseling and a PA program would be during cancer treatment, where patients suffer from the most side effects stemming from disease and treatment.

Conclusion

In summary, the findings of this study suggest that the majority of the patients with advanced lung cancer did not meet the recommended level of MVPA; however, they are interested in receiving PA counseling and joining PA programs. Social support and self-efficacy are key to promoting higher levels of MVPA. Notably, higher level of social support was associated with higher levels of MVPA, and the association was mediated by self-efficacy. This sheds light on the relationship between social support and MVPA, and the established mediating model provides insights into designing PA programs and targeting the mediating variable, self-efficacy, to enhance the level of MVPA. The findings of this study are of paramount importance as they can be used to guide future PA interventions that are favorable to patients with advanced lung cancer, thereby enhancing their interest and adherence to participate in MVPA.

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Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code availability Not applicable.

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Ethics approval was granted by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB) (UW18-502).

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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