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ORIGINAL ARTICLE

Demographic, clinical, lifestyle-related, and social-cognitive correlates of physical activity in head and neck cancer survivors

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Abstract

Purpose The purpose of the study is to identify demographic, clinical, lifestyle-related, and social-cognitive correlates of physical activity (PA) intention and behavior in head and neck cancer (HNC) survivors using the theory of planned behavior (TPB).

Methods Data from two cross-sectional studies on correlates of PA in HNC survivors were pooled. Both studies used self-reports to assess PA and social-cognitive correlates. Potential correlates were collected via self-report or medical records. Univariable and multivariable multilevel linear mixed-effects models were built to identify correlates of PA intention and PA behavior (*Z* scores). Structural equation model analyses were conducted to study the full TPB model in one analysis, taking into account relevant covariates.

Results In total, 416 HNC survivors were surveyed. Their mean (SD) age was 66.6 (9.4) years; 64% were men, and 78% were diagnosed with laryngeal cancer. The structural equation model showed that PA intention was significantly higher in HNC survivors with a history of exercising, who had a more positive attitude, subjective norm, and perceived behavioral control. Patients with higher PA intention, higher PBC, a lower age, and without unintentional weight loss or comorbidities had higher PA behavior. The model explained 22.9% of the variance in PA intention and 16.1% of the variance in PA behavior.

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Conclusions Despite significant pathways of the TPB model, the large proportion variance in PA intention and behavior remaining unexplained suggests the need for better PA behavior (change) models to guide the development of PA promotion programs, particularly for the elderly. Such programs should be tailored to comorbidities and nutritional status.

Keywords Exercise · Social-cognitive models · Head and neck neoplasm

Introduction

There is increasing evidence from randomized controlled trials that regular physical activity (PA) has beneficial effects on health and health-related quality of life (HRQoL) in cancer survivors [31, 32, 42]. PA levels of cancer survivors tend to decrease during cancer treatment. Although they increase during the post-treatment period, they typically do not return to pre-treatment levels [12, 21].

Little is known about the PA behavior of survivors of head and neck cancer (HNC). During treatment, HNC survivors often face severe treatment-related toxicities that differ from survivors of other types of cancer, and they may be at high risk of malnutrition [20]. In addition, a substantial proportion of HNC survivors have suboptimal health literacy [27]. This may impact short-term and long-term PA behavior. Results from a recent survey among 172 HNC survivors showed a decrease in PA from pre-treatment to post-treatment [39]. Patients with higher levels of PA post-treatment had higher HRQoL [39]. A previous cross-sectional study among 59 HNC survivors who were on average 18 months after diagnosis showed that only a small proportion of HNC survivors participated in moderate to vigorous PA, and those who had higher levels of PA were less fatigued and had a higher HRQoL [36]. HNC survivors have reported various barriers to becoming physically active, including HNC-specific symptoms such as dry mouth, difficulty with eating, shortness of breath, and muscle weakness [35]. In addition to treatment-related symptoms, social-cognitive factors, such as enjoying being physically active, were most strongly correlated with PA [35].

Understanding correlates of PA behavior may aid the development of interventions promoting PA behavior for HNC survivors. Interventions based on behavior change theories have been shown to be more effective in improving behavior than those not based on theory [19], and interventions based on a social-cognitive model have shown to be promising to improve PA behavior in cancer survivors [44].

In survivors of other types of cancer, including breast, colorectal, prostate, bladder, gynecological, and kidney cancer [7, 13, 24, 25, 43, 45], the theory of planned behavior (TPB) has been used to identify correlates of PA behavior. The TPB postulates that intention is the immediate determinant of behavior because it reflects a conscious decision to perform or not perform the behavior [5]. Intention, in turn, is determined by three conceptually distinct constructs: attitude, subjective norm, and perceived behavioral control (PBC). An attitude is a person's state of mind regarding certain objects and behaviors, in this case PA. Attitudes are primarily shaped by personal experiences. Subjective norm represents the perceived social pressure that individuals may feel to perform or not perform the behavior. PBC refers to the belief that one is capable of executing a certain course of action, and it may directly predict behavior if it is an accurate reflection of actual control, also known as self-efficacy [5]. In previous studies in cancer survivors, intention and PBC have explained 14–42% of the variance in PA, and attitude, subjective norm and PBC 23–69% of the variance in intention, with variations across cancer types [7, 13, 24, 25, 43, 45].

Except for a few pilot studies [30, 53], PA interventions in HNC survivors have primarily focused on functional training to prevent speech, swallowing, and shoulder problems [1, 10, 11], rather than on improving PA to promote physical fitness and health [20]. Because of the scarcity of information on PA and its social-cognitive correlates in HNC survivors, and to aid in the development of future theory-based interventions to promote PA in this population, we aimed to identify social-cognitive correlates of PA using the TPB model in addition to demographic, clinical, and lifestyle-related correlates in a large group of HNC survivors.

Methods

To increase sample size for the current analysis, we pooled data from two cross-sectional studies that used similar questions to assess social-cognitive variables. In the first study (further referred to as the Laryngectomy study), all members from the Dutch Association for Laryngectomized Patients living in the Netherlands were invited to complete a survey in May 2014, either online or via the regular mail. The study was approved by the Medical Ethics Committee of the VU University Medical Center.

In the second study (further referred to as HNC_{mixed} study), a mail survey was sent to adult survivors of a primary head and neck squamous cell carcinoma living in the Netherlands, who were treated with curative intent within the past 5 years. Eligible patients for this study were identified via the tumor registry of the Netherlands Cancer Institute. This study was approved by the Medical Ethics Committee of the Netherlands Cancer Institute. In both studies, a single reminder was sent to initial nonresponders after 2 or 3 weeks. All participants signed an informed consent statement prior to participation.

Assessment of physical activity

Both studies measured PA using self-report. The Laryngectomy study used the 13-item Physical Activity Scale for the Elderly (PASE) questionnaire [50, 51]. Participants were asked to report the frequency and duration of leisure time, household, and work-related physical activities in the past 7 days. The frequency of activities was recorded as never, seldom (1 to 2 days/week), sometimes (3 to 4 days/week), or often (5 to 7 days/week). Duration of activities, except work, was categorized as less than 1 h, between 1 and 2 h, between 2 and 4 h, or more than 4 h. Work was categorized as less than 1 h, between 1 and 4 h, between 5 and 8 h, or more than 8 h [52]. The total sum score was computed by multiplying the amount of time spent on each activity in (hours/week) by the published empirically derived item weights and summing over all the activities [50]. The PASE has good content validity and good to excellent test-retest reliability in patients with cancer [29].

The HNC_{mixed} study used the long version of the Dutch International Physical Activity Questionnaire (IPAQ) [14], which assesses leisure time, household, transportation, and work-related physical activities over the past week. The IPAQ has good test-retest reliability, and evidence supports its construct validity in the general population of multiple countries [14]. The IPAQ contains four PA domains: (1) work; (2) transportation; (3) house work, house maintenance, and caring for family; and (4) recreation, sport, and leisure time. In addition, it measures the amount of time spent sitting. Time spent in each of the domains was multiplied by corresponding metabolic equivalent of task (MET) values (representing the factor by which resting metabolism increases due to the activity) [2–4], resulting in sum scores for total PA in MET minutes per week.

To pool the data from the two questionnaires, we calculated *Z* scores for each participant by subtracting the sample means and dividing by the standard deviation of the respective scores of each questionnaire. Because the distributions of the data from both questionnaires were skewed to the right, we log-transformed the data before calculating the *Z* scores.

Demographic, clinical, and lifestyle-related variables

Demographic characteristics were obtained by self-report and included age, sex, education (higher vocational education or university versus lower), and having a partner.

Clinical data were collected from medical records (HNC_{mixed} study) or by self-report (Laryngectomy study) and included diagnosis, time since treatment, type of treatments, and comorbidity. The number of different treatment types was dichotomized into < 2 versus ≥ 2. Comorbidity was dichotomized into none versus one or more of the following not further specified comorbidities: pulmonary diseases, diabetes, cardiovascular disease, kidney diseases, neurological diseases, thyroid disease, rheumatic disorders, or musculoskeletal problems. As an indicator of malnutrition risk, participants filled out a single-item question reporting whether or not they recently lost weight unintentionally.

Current alcohol consumption was assessed by self-report and dichotomized into any or none. Body mass index (BMI) was calculated from self-reported height and weight. Exercise history was assessed by self-report and categorized as yes, if patients had exercised prior to diagnosis, and otherwise as no.

Constructs of the theory of planned behavior

Intention was assessed by a single item "I intend to exercise regularly over the next month," rated on a seven-point Likert scale (strongly disagree to strongly agree). The score was linearly transformed to 0–100, with a higher score representing a more positive intention towards PA.

Attitude was assessed by seven bipolar adjective scales covering affective (enjoyable-unenjoyable, interesting-boring, pleasant-unpleasant) and instrumental (useful-useless, beneficial-harmful, wise-foolish, good-bad) aspects of attitude. The statements were preceded by "physical activity is…." The Cronbach's alphas for the affective and instrumental attitude scales were 0.93 and 0.87, respectively, and the correlation (r_p) between the two scales was 0.75. We combined the two scales into an overall attitude scale ($\alpha = 0.94$), and the mean score of the seven items was linearly transformed to 0–100 and used for further analysis. A higher score represents a more positive attitude towards PA.

Subjective norm was assessed by a single item: "Most people who are important to me think I should exercise regularly" rated on a five or seven-point Likert scale (strongly disagree to strongly agree). Scores were linearly transformed to 0–100, with a higher score representing a more positive subjective norm regarding PA.

Perceived behavioral control was assessed by rating the perceived confidence in being able to exercise regularly in four different situations, including bad weather, having no interest, having physical complaints, and being under personal stress. Items were scored on a five or seven-point Likert scale (strongly disagree to strongly agree), and scores were linearly transformed to 0–100. Crohnbach's alpha for the scale was 0.81, and we used the mean score for further analysis. Higher scores represent a higher PBC.

Statistical analysis

Descriptive information of normally distributed variables is presented as mean and standard deviation (SD), and we used median and interquartile range (IQR) otherwise.

Univariable and multivariable multilevel linear mixed-effect models were built to identify correlates of PA intention and PA behavior (*Z* scores), in which the clustering of patients within studies was taken into account by using a random intercept on study level. Multivariable models were built in two steps. First, we selected the demographic, clinical, and lifestyle-related correlates using a backward selection procedure, in which variables with $p > 0.10$ were removed from the model one by one. In the second step, we entered the social-cognitive variables into the regression models obtained in step 1. The models' regression coefficients and 95% confidence intervals (CI) are presented. Marginal explained variances of the models were calculated [22, 33]. These analyses were conducted in IBM SPSS Statistics 22 and R 3.3.

Next, we used a structural equation model (SEM) to examine the full TPB model in one analysis, including relevant demographic, clinical, and lifestyle-related correlates selected from the linear mixed-effect models using the piecewise SEM package in R [28]. Model fit was evaluated using Shipley's test of directed separation [40], which uses Fisher's C statistic [41]. A significant Shipley's test indicates that there are one or more relationships between the variables in the model that are not yet included in the model.

Results

In total, 284 (response rate 33%) HNC survivors participated in the Laryngectomy study, of whom 142 completed the survey online and 142 via paper and pencil, and 132 (response rate 52%) HNC survivors participated in the HNC_{mixed} study. Consequently, survey data from 416 HNC survivors were available for the current analyses.

Participants were on average 66.6 (SD 9.4) years old; 64% were men, and 78% were diagnosed with cancer of the larynx (Table 1). Median time since treatment was 54 months, and 70% were treated with multiple treatment modalities. Unintentional weight loss was present in 11% of participants, and comorbidities were present in 37%, with cardiovascular problems (20%), musculoskeletal problems (11%), and thyroid disease (9%) rated as most common problems.

Mean scores on TPB variables ranged from 51.7 for PBC to 80.0 for attitude. Median PASE score of participants from the Laryngectomy study was 106.7, and median IPAQ score of participants from the HNC_{mixed} study was 3510 MET minutes/week (Table 1).

Correlates of physical activity intention and behavior

Univariable and multivariable associations with PA intention and PA behavior are presented in Tables 2 and 3, respectively. PA intention was significantly higher in HNC survivors who had a history of exercising (Table 3). No significant associations were found for demographic and clinical characteristics. HNC survivors with more positive attitudes, subjective norms, and PBC had higher PA intention.

PA behavior was significantly higher in HNC survivors who were younger, had not lost weight unintentionally, and had no comorbidities (Table 3). Additionally, PA intention and PBC were significantly associated with PA behavior.

Also, the path analysis showed that a more positive attitude, subjective norm, and PBC and a history of exercising were associated significantly with a higher PA intention and that a higher PA intention, PBC, a younger age, and the absence of unintentional weight loss and comorbidities were associated significantly with a higher PA behavior (Table 4, Fig. 1). The model explained 22.9% of PA intention and 16.1% of PA behavior. Fisher's C of the SEM model was 27.48 ($df = 14$, $p = 0.017$), suggesting that one or more relationships between the variables were not included in the model. The missing path analysis indicated a direct path from attitude to PA behavior. Adding this association to the SEM model increased the explained variance for PA behavior to 19.1% and improved the model fit ($C = 14.4$, $df = 12$, $p = 0.276$).

Discussion

This study evaluated the TPB model in a relatively large group of HNC survivors and showed that attitude, subjective norm, and PBC were significantly associated with PA intention and that PA intention and PBC were significantly associated with PA behavior. Additionally, we found higher PA intention in HNC survivors who had a history of exercising and higher PA behavior in survivors who were younger, and without unintentional weight loss and comorbidities. However, the model explained only a small proportion of the variance in PA intention and PA behavior.

Overall, the TPB model explained 22.9% of the variance in PA intention and 16.1% of the variance in PA behavior. Although, this is comparable to the 23 and 14%, respectively, reported in a study of women during treatment for breast cancer [13], it is generally low compared to findings in studies that applied the TPB model in other types of cancer [7, 24, 25, 43, 45]. The current study confirms the relevance of social-cognitive constructs in explaining PA behavior in HNC survivors observed in previous research [35, 37]. The low amount of variance in PA intention and behavior explained and the poor model fit indicate the need for better suitable or additional behavior theories to explain behavior in HNC survivors that can assist in developing interventions to promote PA behavior. In fact, a better model fit was found when attitude was directly associated with PA behavior, indicating that the behavior is not fully intentional. This intention-behavior gap has previously been acknowledged [34], also in survivors of cancer types other than HNC [46]. Coping and planning, i.e., the anticipation of PA barriers and the design of alternative actions, as well as coping and maintenance self-efficacy, are

Table 1 Descriptive values of demographic, clinical, and lifestyle-related characteristics, social cognitive variables, and physical activity of HNC survivors ($n = 416$)

	Laryngectomy	HNC_{Mixed}	Total
Demographic variables			
N	284	132	416
Age, mean (SD) (years)	67.9 (8.8)	63.6 (10.1)	66.6 (9.4)
Gender, *n* (%) male	237 (84)	102 (77)	339 (82)
Partner, *n* (%) yes	202 (71)	103 (78)	305 (73)
Education, *n* (%) high	56 (20)	42 (32)	98 (24)
Clinical variables			
Diagnosis, *n* (%)			
Larynx	284 (100)	40 (30)	324 (78)
Other	0 (0)	92 (70)	92 (22)
Treatment, *n* (%)			
Laryngectomy	284 (100)	2 (2)	286 (69)
Surgery other	0 (0)	40 (30)	40 (10)
Radiotherapy	250 (89)	62 (50)	312 (76)
Chemotherapy	27 (10)	11 (8)	38 (9)
Chemoradiation	NA	35 (27)	35 (8)
PDT	0 (0)	6 (5)	6 (1)
Brachytherapy	0 (0)	5 (4)	5 (1)
CO_2 laser	0 (0)	13 (10)	13 (3)
Multiple treatment modalities	250 (88)	39 (30)	289 (70)
Time since treatment, median (IQR) (months)	78 (36; 168)	44 (32; 53)	54 (33; 120)
Comorbidity[a], *n* (%)	113 (40)	41 (31)	154 (37)
Lung disease	26 (9)	5 (4)	31 (12)
Cardiovascular disease	16 (6)	5 (4)	21 (8)
Diabetes	59 (21)	20 (15)	79 (19)
Kidney disease	5 (2)	1 (1)	6 (1)
Neurological disease	4 (1)	4 (3)	8 (2)
Rheumatic disease	27 (10)	0 (0)	27 (6)
Musculoskeletal problems	29 (10)	15 (11)	44 (11)
Thyroid disease	35 (12)	4 (3)	39 (9)
Unintentional weight loss, *n* (%)	27 (10)	18 (14)	45 (11)
BMI, mean (SD) (kg/m^2)	26.1 (4.8)	24.6 (3.6)	25.6 (4.5)
Underweight (BMI < 18.5), *n* (%)	3 (1)	3 (2)	6 (1)
Normal weight (BMI 18.5–25), *n* (%)	122 (43)	74 (56)	196 (47)
Overweight (BMI 25–30), *n* (%)	113 (40)	48 (36)	161 (39)
Obese (BMI ≥ 30), *n* (%)	44 (16)	7 (5)	51 (12)
Lifestyle-related variables			
Current alcohol consumption, *n* (%) yes	199 (70)	83 (63)	282 (68)
Exercise history, *n* (%) yes	174 (62)	89 (79)	263 (67)
Social-cognitive variables (0–100)			
Intention, mean (SD)	77.9 (31.3)	61.2 (35.8)	72.6 (33.7)
Attitude, mean (SD)	79.8 (21.3)	80.4 (21.8)	80.0 (21.4)
Subjective norm, mean (SD)	73.3 (30.1)	55.1 (31.8)	67.5 (31.8)
Perceived behavioral control, mean (SD)	53.6 (26.7)	47.3 (24.6)	51.7 (26.2)
Physical activity			
Score PASE, median (IQR) points	106.7 (58.3; 164.7)		
Score IPAQ, median (IQR) MET minutes/week		3510 (1563; 6131)	

IPAQ International Physical Activity Questionnaire, *IQR* interquartile range, *NA* not assessed, *PA* physical activity, *PASE* Physical Activity Scale for the Elderly, *PDT* photodynamic therapy, *SD* standard deviation

[a] One or more out of eight comorbidities

strategies to account for the intention-behavior gap [34], and they may be worth further investigation in HNC survivors.

Our finding that younger patients are more physically active confirms results from previous studies in cancer survivors [9, 15, 23], including HNC [48], and suggests that interventions promoting PA behavior in HNC survivors should particularly target the older ones. Studies among the older, general adult population have observed high levels of sedentary behavior [8], and that PA is hampered by poor health and lack of interest [18] and is facilitated by motivational (e.g., self-efficacy, outcome expectations, goal setting, action planning, and control) and environmental (e.g., neighborhood safety and access to PA) determinants [49]. More research is needed to identify PA barriers and modifiable motivational determinants that should be addressed in interventions specifically aiming to promote PA among older cancer survivors including HNC.

A limited number of studies evaluating PA interventions specifically targeting the elderly cancer population have

Table 2 Univariable multilevel associations of demographic, clinical, lifestyle-related, and social-cognitive variables with physical activity intention and behavior ($n = 416$)

	PA intention	PA behavior
	β (95% CI)	β (95% CI)
Demographic		
Older age (year)	− 0.06 (− 0.41; 0.29)	− 0.02 (− 0.03; − 0.008)*
Female	− 0.45 (− 8.67; 7.77)	0.05 (− 0.20; 0.30)
Having a partner	0.41 (− 6.83; 7.65)	0.14 (− 0.08; 0.35)
Higher education	6.72 (− 0.81; 14.26)**	0.08 (− 0.15; 0.31)
Clinical		
Time since treatment (year)	0.38 (− 0.11; 0.87)	0.007 (− 0.006; 0.02)
Multiple treatment modalities	1.15 (− 7.33; 9.63)	0.15 (− 0.06; 0.36)
Comorbidity	− 6.41 (− 13.02; 0.20)**	− 0.30 (− 0.50; − 0.10)*
Unintentional weight loss	− 9.66 (− 20.14; 0.81)**	− 0.50 (− 0.81; − 0.19)*
BMI	0.05 (− 0.68; 0.78)	− 0.003 (− 0.02; 0.02)
Lifestyle-related		
Current alcohol consumption	− 0.43 (− 7.33; 6.47)	0.06 (− 0.14; 0.27)
Exercise history	13.60 (6.69; 20.51)*	0.18 (− 0.03; 0.38)**
Social cognitive		
Intention	–	0.007 (0.005; 0.010)*
PBC	0.40 (0.28; 0.51)*	0.008 (0.004; 0.011)*
Attitude	0.55 (0.40; 0.69)*	–
Subjective norm	0.32 (0.22; 0.42)*	–

BMI body mass index, *CI* confidence interval, *PA* physical activity, *PBC* perceived behavioral control

*$p < 0.05$; **$0.05 \le p < 0.10$

Table 3 Multivariable multilevel associations with PA intention and PA behavior

	β (95% CI)	Explained variances
PA intention		
Step 1		3.6%
Exercise history	13.60 (6.69; 20.51)*	
Step 2		22.9%
Exercise history	7.56 (1.08; 14.07)*	
Attitude	0.39 (0.24; 0.53)*	
Subjective norm	0.21 (0.11; 0.31)*	
PBC	0.25 (0.14; 0.37)*	
PA behavior		
Step 1		8.7%
Higher age (year)	− 0.02 (− 0.03; − 0.01)*	
Time since treatment (year)	0.02 (0.004; 0.03)*	
Unintentional weight loss	− 0.45 (− 0.75; − 0.15)*	
Comorbidity	− 0.31 (− 0.50; − 0.11)*	
Step 2		15.8%
Higher age (year)	− 0.02 (− 0.03; − 0.01)*	
Time since treatment (year)	0.01 (− 0.004; 0.02)	
Unintentional weight loss	− 0.37 (− 0.66; − 0.08)*	
Comorbidity	− 0.27 (− 0.45; − 0.09)*	
Intention	0.005 (0.003; 0.008)*	
PBC	0.005 (0.001; 0.008)*	

CI confidence interval, *PBC* perceived behavioral control

*$p < 0.05$

Table 4 Model parameter estimated by the structural equation model

	Estimate	Standard error	*p* value	Explained variances
Association with PA intention				22.9%
Attitude	0.247	0.047	< 0.001	
Subjective norm	0.196	0.047	< 0.001	
PBC	0.198	0.047	< 0.001	
Exercise history	0.106	0.047	0.02	
Associations with PA behavior				16.1%
Intention	0.179	0.048	< 0.001	
PBC	0.118	0.048	0.013	
Age (years)	− 0.224	0.048	< 0.001	
Time since treatment (year)	0.069	0.050	0.175	
Unintentional weight loss	− 0.115	0.047	0.014	
Comorbidity	− 0.131	0.045	0.004	

PA physical activity, *PBC* perceived behavioral control

shown beneficial effects on physical fitness, functional independence, and quality of life [26]. However, such interventions are complicated by the relatively high proportion of comorbidities present in the elderly cancer population [26]. We confirmed the finding that comorbidities may form a barrier to PA in HNC survivors [35], and this was independent from age. It is therefore important to gain more understanding on how to motivate and support patients with comorbidities to be physically active. PA promotion interventions should be tailored to the specific comorbidities of individual cancer survivors [47]. Specific attention must also be paid to unintentional weight loss, as this may indicate malnutrition, forming a barrier to PA behavior. Additional nutritional counseling should be recommended for patients with malnutrition [6].

Previous research has demonstrated that demographic and clinical correlates of PA may differ across cancer types [15]. This, in fact, provided the rationale for investigating correlates of PA in HNC survivors. The lack of significant associations observed for most demographic and clinical variables with PA confirms findings from previous studies in HNC survivors [39, 48], although results from a study by Rogers et al. [35] suggested that HNC-specific symptoms may form barriers to PA. Clinical variables and associated symptoms may be more strongly associated with PA in patients during or shortly their cancer treatment, compared to patients who completed treatments longer ago, as in our sample. Prospective studies in the HNC population are therefore warranted, to determine the extent to which correlates of PA behavior remain stable or vary over the cancer (treatment) continuum [39].

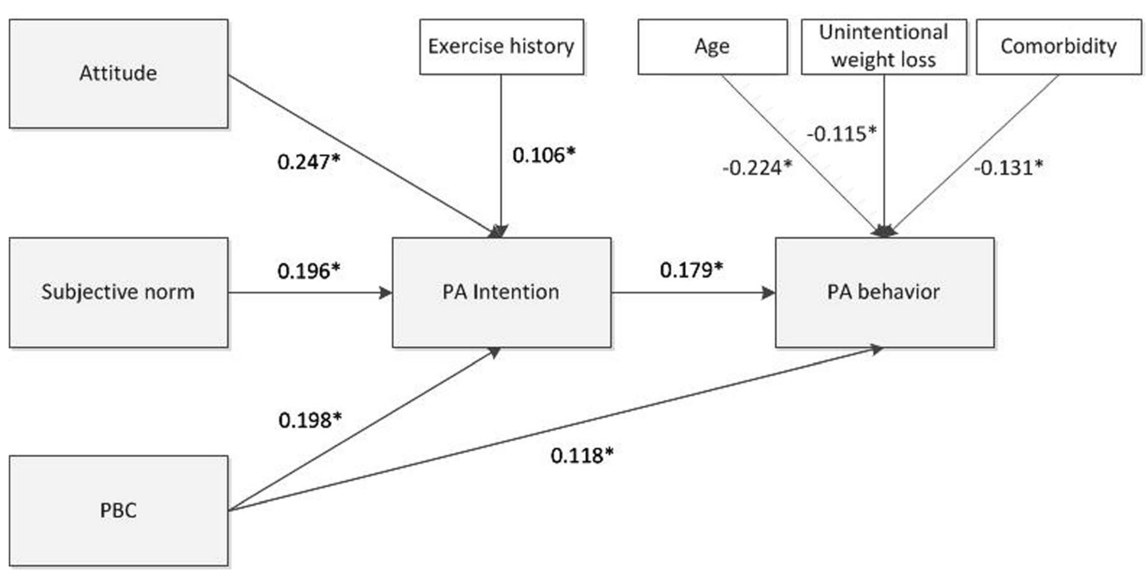

Fig. 1 Standardized parameter estimates for the theory of planned behavior model in head and neck cancer survivors. PA physical activity, PBC perceived behavioral control. *$p < 0.05$

We found that exercise history was associated significantly with PA intention, which, according to the TPB model, is the main factor driving PA behavior [5]. Habits have been recognized as an important determinant of behavior [16], both in initiating and in performing a behavior [17]. Our study found an association between habits and PA intention, but not with behavior. It may be that longer term survivors have developed a new lifestyle that is less strongly associated with pre-cancer behavior. Our finding in this regard should, however, be interpreted with caution because the majority of the HNC survivors in our study reported having a history of exercising, but this was based on self-report. This may have introduced recall bias [38], particularly in longer term survivors.

Strengths of this study are the application of the TPB model with path analyses in a large group of HNC survivors. Nevertheless, the study had several limitations. First, to obtain the large sample, data from two studies with a different recruitment strategy were merged. In both studies, response rates were relatively low, and it may be that those who were more interested in PA were more likely to participate. This may have resulted in an overestimation of PA levels. Additionally, laryngectomized survivors were overrepresented in our sample of HNC survivors. This hampers the generalizability of the results to all patients with HNC. The observed associations, however, are most likely valid. Second, PA behavior was assessed using two different self-report measures, with Z scores being calculated to enable pooling. Despite the use of validated questionnaires, self-reports are prone to recall bias and likely to overreport or underreport PA levels. Additionally, by transforming the scores using a standardized value of the log-transformed scores, the clinical meaning of the regression coefficients can no longer be directly inferred. Yet, the relative importance of each explanatory variable can still be judged from the analyses. Third, we assessed attitude, subjective norm, and PBC directly and were not able to incorporate the underlying beliefs, as they were not assessed in a similar way across the studies. The failure to include these underlying beliefs in our models may have contributed, in part, to the low levels of explained variances in PA intention and behavior that were observed. Finally, due to the cross-sectional design, no inferences can be made regarding causality.

Considering the positive association between PA and HRQoL in HNC survivors [36, 39, 48], it may be important to develop interventions to improve PA in this population. The effectiveness of such interventions may be improved by applying appropriate behavior change theories and strategies [44]. Our results showed that the TPB model alone may be of only limited value in explaining PA behavior, and thus in designing interventions to promote PA in HNC survivors. Interventions to promote PA in HNC survivors should specifically address barriers associated with, e.g., comorbidity and poor nutritional status, and not rely solely on improving PBC and intention. The development of such interventions should consider using models that account for the intention-behavior gap.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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