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Exercise behavior in cancer survivors and associated factors

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Abstract
Introduction Physical activity is an important component in promoting a healthy life style in cancer survivors. We estimated the proportion of cancer survivors who are physically active, defined as meeting public health exercise guidelines, and changes in level of physical activity (LPA) from before diagnosis to after treatment. We also identified medical and demographic factors associated with LPA and its changes.
Methods A cross-sectional survey assessing LPA before diagnosis and after treatment, together with demographic and medical variables in 975 cancer survivors.
Results Forty-five percent of the cancer survivors were physically active after treatment. Before diagnosis and after treatment 33% were active, whereas 40% were inactive at both time points. Fifteen percent were active before diagnosis but inactive after treatment, and 12% were inactive before diagnosis but active after treatment. Increasing age and weight, low education, comorbidity and smoking were associated with physical inactivity after treatment. Change in LPA from active to inactive was associated with comorbidity, distant disease and smoking, while a change from inactive to active was associated with high education.
Conclusions Less than half of cancer survivors were physically active. Almost three quarters of cancer survivors remained stable in LPA. The remaining quarter changed LPA, with slightly more cancer survivors becoming inactive than active. Age, weight, education, comorbidity, disease stage and smoking can identify survivors at risk of physical inactivity after treatment.
Implications for cancer survivors Recognizable variables can be used to identify physically inactive cancer survivors after treatment and give these survivors support to start or maintain LPA.

Keywords Exercise guidelines · Physical activity change · Cancer survivors

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Introduction

The number of cancer survivors is increasing and estimates show that over 900,000 people in the Nordic countries are living with ongoing cancer or a history of cancer [1]. Approximately 65% diagnosed with cancer in the Western world today can expect to live for at least 5 years [2, 3]. Due to the malignancy itself and its treatment, many patients experience various acute and chronic adverse effects that affect quality of life (QoL) [4–6]. Compared to the general population, cancer survivors also face a higher risk of secondary cancer, osteoporosis, overweight and cardiovascular diseases [7–10]. In general, there is substantial documentation showing that physical activity (PA) prevents or at least reduces some of these adverse effects [11]. Several studies have recently shown positive effects of PA among cancer survivors both on physical and psychological health, and overall QoL [12–14], as well as an association between PA and survival [15, 16].

Despite documented benefits of exercise, only 25–30% of cancer survivors are reported to be physically active [17–20]. Physically active individuals are in this report defined as individuals who meet the public health exercise guidelines [21]. Admittedly these guidelines have changed over time and may vary between countries [21, 22] (www.helsedirektoratet.no). Young age, male, high education, healthy weight and absence of comorbidity are factors shown to be to be positively associated with PA among cancer survivors [20, 23–27].

Studies indicate that about 30–60% of cancer survivors who were active before diagnosis do not return to their pre-diagnosis level of physical activity (LPA) [28, 29], but factors associated with change in LPA have received limited attention. However, Lynch and colleagues found that being female, low level of education and having received adjuvant therapy were associated with a decrease in LPA from pre-diagnosis to post-treatment among colorectal cancer patients [26]. In order to reduce morbidity after cancer treatment, the goal should be to increase the number of physically active cancer survivors. Identification of demographic and medical factors associated with LPA and its changes may provide important knowledge about the risk to be a physically active or an inactive cancer survivor. Interventions focusing on PA should primarily focus on the latter individuals.

The primary aim of the present study was 1) to estimate the proportion of physically active cancer survivors and to assess the percentage of individuals who change their LPA from before diagnosis to after treatment. The secondary aim was to identify medical and demographic factors associated with LPA and its changes. Based on previous research in cancer survivors [17–20, 23–28], we hypothesized that at least one quarter of Norwegian cancer survivors would be physically active. Further, we hypothesized that about one third of cancer survivors would report a lower LPA after treatment than before diagnosis. We expected that age, weight, education, comorbidity and smoking, treatment or extension of the disease (stage) would be associated with LPA and its changes from before diagnosis to after treatment.

Materials and methods

Study participants and procedure

This cross-sectional study was conducted from February 2007 to September 2007. Consecutive patients were identified from the Norwegian Radium Hospital (NRH)'s patient registry and were eligible for the analysis if the medical databases did not show any disease activity at the time of the survey, with exception of testicular cancer and malignant lymphoma, since many of these patients are cured despite metastases at time of diagnosis. Patients were aged between 18 and 75 when first seen at the hospital. They had received curatively intended treatment at the NRH between January 2002 and December 2005 for malignant lymphoma, breast, testicular, cervical, ovarian or prostate cancer. Among all available breast cancer patients only a random third was selected because of the large number in this group. Due to small groups, cervical cancer and ovarian cancer were combined as 'gynecological cancer' in the analyses. Treatment (except for adjuvant hormone treatment) should have been finalized prior to the study.

Eligible participants received an information letter, a questionnaire and a pre-paid envelope, with a follow-up reminder letter to non-responders after four weeks. Ethical approval was obtained from the institutional review board and the regional ethics committee for medical research. All participants signed an informational consent form.

Measures

Information on gender, age, diagnosis, time since diagnosis and disease stage (localized/regional/distant) was collected from the medical databases at the hospital. The remaining variables were obtained by self-report and included: weight and height, married/cohabitant, education, employment status, comorbidity [defined as any long-lasting physical or psychological illnesses (cancer excluded) which had led to reduced daily life functions during the last year], treatment [one local treatment/two local treatments/systemic treatment/one local treatment + systemic treatment/two local treatments + systemic treatment (local treatment including surgery and/or radiotherapy and systemic treatment including chemotherapy and/or hormone therapy)], and daily smoking.

The patients recorded their LPA prior to diagnosis and their post-treatment LPA (at the time of survey) by a modified version of the Leisure Score Index from the *Godin Leisure Time Exercise Questionnaire (GLTEQ)* [30]. The GLTEQ assesses average frequency and duration of intensity: mild (e.g. easy walking), moderate (e.g. brisk walking) and vigorous (e.g. running) exercise in a typical week. The GLTEQ has been found to be both valid and reliable [31]. Two independent translators following standard forward and backward translation procedures translated the GLTEQ into Norwegian [32]. In our study the proportion of respondents meeting exercise guidelines (counted as ≥150 min of moderate intensity or ≥75 min of vigorous intensity a week) was calculated considering LPA before diagnosis and LPA after treatment separately [21]. Patients not meeting the public exercise guidelines were categorized as physically inactive, irrespective of the individual level of sub-optimal activity.

Change in LPA resulted in four post-treatment categories, taken into account whether or not respondents were meeting exercise guidelines at the two time points: *"maintainers"*: meeting exercise guidelines at both time points, *"persistently*

inactives": not meeting exercise guidelines before diagnosis or after treatment, *"adopters"*: not meeting exercise guidelines before diagnosis but after treatment, *"relapsers"*: meeting exercise guidelines before diagnosis but not after treatment.

Statistical analyses

Except for descriptive methods, logistic regression analyses were used to evaluate factors associated with 1: being physically active versus being inactive after treatment, 2: being a relapser versus being a maintainer and 3: being an adopter versus being persistently inactive. Demographic and medical variables statistically significant in unadjusted analyses were included as explanatory variables in the multiple regression analyses. The final models were reduced to include statistically significant variables only. Gender was not included as an explanatory variable in the logistic regression analyses because four out of five diagnoses were gender-specific, which made it impossible to separate diagnosis and gender in overall analyses. Adjusted odds ratios (aOR) are presented with 95% confidence intervals (95% CI). All analyses were performed with SPSS 16.0 (SPSS, Chicago, IL). A two-tailed *P* value of less than 0.05 was considered statistically significant.

Results

Participant compliance

Of 2,024 patients who were invited to participate in the survey, 43 envelopes were returned unopened (19 persons had moved to an unknown address and 24 were recently deceased). Of 1,981 eligible participants, 1,356 returned the completed questionnaire package. Of these, 72 patients were excluded because of recurrence at the time of survey according to the medical database, resulting in 1,284 participants. Due to missing responses as to GLTEQ, we had 975 analyzable participants and a response rate of 51% (975 of 1,909). Fifty-six percent were female, 75% were married/cohabitant and 42% had high education (Table 1). The median age was 56.1 years (range 21.6–80.0) and the median number of months since diagnosis was 41.0 (range 14.3–103.5) (data not shown).

Prevalence of cancer survivors being physically active and changes in LPA

Based on the overall sample of 975 cancer survivors reporting their LPA both pre-diagnosis and post-treatment, 48% of the participants were physically active before diagnosis and 45% were physically active after treatment

Table 1 Demographic and medical characteristics of participants

Variable	Total *n* (%)
No. of participants	975
Demographic	
Gender	
Male	432 (44)
Female	543 (56)
Age (years)	
Middle-aged adult 45–64	464 (48)
Young adult <45 years	265 (27)
Older adults ≥65	246 (25)
BMI (*n*=934)	
Healthy <25 kg/m^2	445 (48)
Overweight 25–29.9 kg/m^2	350 (37)
Obese ≥30 kg/m^2	139 (15)
Married/cohabitant (*n*=974)	
No	248 (25)
Yes	726 (75)
Education (*n*=972)	
Primary/secondary school	157 (16)
High school	412 (42)
College/university <4 yrs	223 (23)
College/university ≥4 yrs	180 (19)
Employment status (*n*=974)	
Fulltime/student/military service	445 (46)
Part-time/homemaker	137 (14)
Retired	217 (22)
Disability benefit/sick leave/unemployed	175 (18)
Medical	
Comorbidity (*n*=945)	
No	664 (70)
Yes	281 (30)
Time since diagnosis	
<2 years	112 (11)
≥2 years	863 (89)
Diagnosis	
Lymphoma	245 (25)
Testicular	139 (14)
Breast	241 (25)
Gynecological (cervix and ovarian)	204 (21)
Prostate	146 (15)
Treatment (*n*=970)	
One local treatment	136 (14)
Two local treatments	155 (16)
Systemic treatment	109 (11)
One local treatment + systemic treatment	356 (37)
Two local treatments + systemic treatment	214 (22)
Disease stage (*n*=972)	
Localized	482 (50)
Regional	297 (30)
Distant	193 (20)
Daily smoking (*n*=972)	
No	812 (84)
Yes	160 (16)

Numbers may not add up to 975 because of missing data

(Fig. 1). The respective figure for physically inactives were 52% and 55%. In total, 323 (33%) maintained physically active both before diagnosis and after treatment, 392 (40%) were persistently inactive, 149 (15%) relapsed in LPA, while 111 (12%) adopted in LPA (Fig. 1). Of the 472 pre-diagnosis physically active survivors, 149 (32%) were categorized as relapsers and 323 (68%) maintained their LPA after treatment (Table 3). Of the 503 pre-diagnosis physically inactive survivors, 111 (22%) became adopters and 392 (78%) were persistently inactive after treatment (Table 4).

Factors associated with being physically active after treatment

In unadjusted logistic regression analyses, being physically active after treatment was negatively associated with age 65+ years, overweight and obesity, retirement, receiving disability benefit/sick leave/unemployment, comorbidity, distant disease and smoking, and was positively associated with higher education (Table 2). Results from multiple logistic regression analyses showed that older age remained negatively associated with being physically active [aOR 0.62; 95% CI (0.44–0.88), p=0.008] (Table 2). Overweight and obesity were also negatively associated with being physically active [aOR 0.73; 95% CI (0.54–0.98), p=0.03 and aOR 0.46; 95% CI (0.3–0.71), p<0.001, respectively]. Participants with comorbidity had approximately 50% reduced odds of being physically active compared to those with no comorbidity [aOR 0.56; 95% CI (0.41–0.76), p< 0.001]. Compared to non-smokers, smokers were about half as likely to be physically active [aOR 0.53; 95% CI (0.36–0.78), p=0.001]. High education was positively associated with being physically active [aOR 2.05; 95% CI (1.26–3.33), p=0.004] (Table 2).

Factors associated with being a relapser and an adopter

In unadjusted analyses, being a relapser was associated with obesity, receiving disability benefit/sick leave/unemployment, comorbidity, distant disease and smoking (Table 3). In multiple logistic regression analyses, presence of comorbidity resulted in about 2.5 higher odds of being a relapser compared to the participants with no comorbidity [aOR 2.47; 95% CI (1.6–3.81), p<0.001] (Table 3). Cancer survivors with distant disease were more than twice as likely to become a relapser compared to the ones with localized disease [aOR 2.17; 95% CI (1.28–3.66), p=0.004]. Smoking also remained associated with being a relapser [aOR 1.79; 95% CI (1.04–3.09), p=0.04]. High education (college/university ≥4 years) was the only factor statistically significantly associated with being an adopter both in unadjusted and multiple logistic regression analysis [aOR 2.29; 95% CI (1.13–4.63), p=0.02] (Table 4).

Discussion

Our study showed that almost half of all surveyed cancer survivors were physically active after treatment. In the overall sample, one third were maintainers, 40% were persistently inactives and about one quarter changed their LPA. Among those being physically active before diagnosis, about one third relapsed in LPA. Among those who were inactive before diagnosis, more than one fifth adopted in LPA. Moreover, the results demonstrated that participants who were 65+ years, those with a non-healthy weight, or low educated, had comorbidities and smoked were less likely to be physically active. Being a relapser was associated with comorbidity, distant disease and smoking, and being an adopter was associated with high education.

The large sample size made it possible to perform subgroup analyses. Further, information on LPA both before diagnosis and after treatment made it possible to perform analyses on the change of LPA across the cancer experience, even though the patients provided the relevant information retrospectively. Validated questionnaires of LPA were applied. Medical variables (diagnosis, time since diagnosis and disease stage) were collected from medical

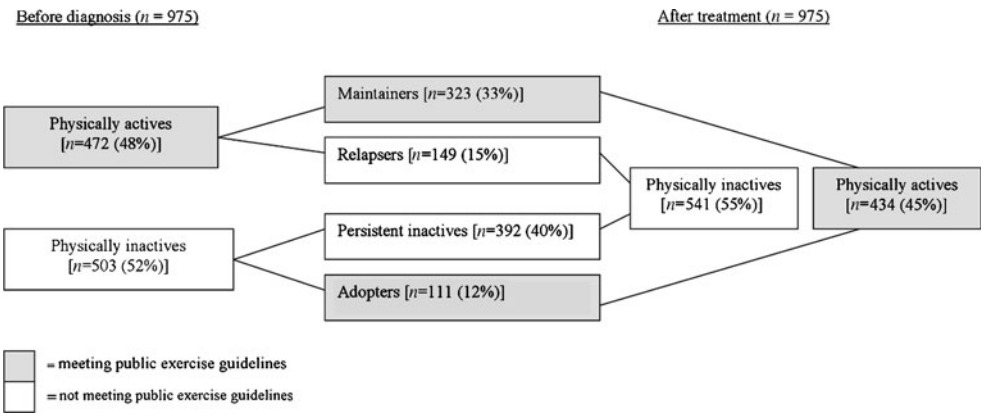

Fig. 1 Categorizing cancer survivors based on whether or not they were meeting exercise guidelines before diagnosis and after treatment (n=975)

Table 2 Prevalence of physically active cancer survivors after treatment and factors associated with being physically active (versus being inactive) (n=975)

	Physically actives%		Unadjusted analyses			Adjusted analyses[a]		
	Yes	No	cOR	95%CI	P	aOR	95%CI	P
All (n=975)	45	55						
N	434	541						
Diagnosis (n=975)								
Lymphoma (reference)	42	58	1.0		0.68			
Testicle	47	53	1.25	0.82–1.89	0.30			
Breast	47	53	1.24	0.87–1.77	0.24			
Gynecological (cervix and ovarian)	42	58	1.01	0.69–1.46	0.98			
Prostate	45	55	1.11	0.73–1.67	0.63			
Age (years) (n=975)								
Middle-aged adult 45–64 (reference)	46	54	1.0		0.06	1.0		0.03
Young adult <45 years	48	52	1.08	0.8–1.47	0.59	0.86	0.62–1.2	0.37
Older adult ≥65	38	62	0.73	0.53–0.99	0.049	0.62	0.44–0.88	0.008
BMI (n=934)								
Healthy <25 kg/m^2 (reference)	51	49	1.0		<0.001	1.0		0.001
Overweight 25-29.9 kg/m^2	43	57	0.75	0.57–0.99	0.046	0.73	0.54–0.98	0.03
Obese ≥30 kg/m^2	30	70	0.42	0.31–0.69	<0.001	0.46	0.3–0.71	<0.001
Married/cohabitant (n=974)								
No (reference)	48	52	1.0					
Yes	43	57	0.83	0.62–1.1	0.2			
Education (n=972)								
Primary/secondary school (reference)	34	66	1.0		0.001	1.0		0.04
High school	42	58	1.42	0.97–2.09	0.07	1.42	0.93–2.16	0.11
College/university <4 yrs	48	52	1.84	1.21–2.81	0.005	1.55	0.97–2.47	0.07
College/university ≥4 yrs	55	45	2.4	1.54–3.73	<0.001	2.05	1.26–3.33	0.004
Employment status (n=974)								
Fulltime/student/military service (reference)	50	50	1.0		0.004			
Part-time/homemaker	44	56	0.77	0.52–1.13	0.18			
Retired	40	60	0.66	0.48–0.92	0.01			
Disability benefit/sick leave/unemployed	35	65	0.54	0.38–0.78	0.001			
Comorbidity (n=945)								
No (reference)	49	51	1.0			1.0		
Yes	33	67	0.53	0.39–0.7	<0.001	0.56	0.41–0.76	<0.001
Time since diagnosis (years) (n=975)								
<2 years (reference)	48	52	1.0					
≥2 years	44	56	0.85	0.57–1.25	0.4			
Treatment (n=970)								
One local treatment (reference)	39	61	1.0		0.2			
Two local treatments	46	54	1.36	0.85–2.17	0.2			
Systemic treatment	37	63	0.91	0.54–1.53	0.72			
One local treatment + systemic treatment	47	53	1.42	0.95–2.12	0.09			
Two local treatments + systemic treatment	46	54	1.32	0.86–2.05	0.21			
Disease stage (n=972)								
Localized (reference)	46	54	1.0		0.04			
Regional	47	53	1.02	0.77–1.37	0.88			
Distant	36	64	0.66	0.47–0.93	0.02			
Daily smoking (n=972)								
No (reference)	47	53	1.0			1.0		
Yes	34	66	0.58	0.41–0.83	0.003	0.53	0.36–0.78	0.001

Numbers may not add up to 975 because of missing data

cOR crude odds ratio, *aOR* adjusted odds ratio. 95% CI, 95% Confidence Interval

[a] Numbers included in the multivariate analyses were 902

Table 3 Prevalence of relapsers and factors associated with being a relapser (versus those maintain active) among actives before diagnosis (n=472)

	Proportion of relapsers%		Unadjusted analyses			Adjusted analyses[a]		
	Yes	No	cOR	95%CI	P	aOR	95%CI	P
All physical active before diagnosis (n=472)	32	68						
N	149	323						
Diagnosis (n=472)								
Lymphoma (reference)	37	63	1.0		0.09			
Testicle	30	70	0.75	0.41–1.37	0.35			
Breast	27	73	0.64	0.37–1.11	0.12			
Gynecological (cervix and ovarian)	39	61	1.08	0.62–1.88	0.79			
Prostate	20	80	0.43	0.21–0.89	0.02			
Age (years) (n=472)								
Middle-aged adult 45–64 (reference)	31	69	1.0		0.25			
Young adult <45 years	36	64	1.28	0.83–1.98	0.26			
Older adults ≥65	26	74	0.81	0.47–1.38	0.44			
BMI (n=454)								
Healthy <25 kg/m^2 (reference)	28	72	1.0		0.02			
Overweight 25–29.9 kg/m^2	33	67	1.26	0.82–1.95	0.3			
Obese ≥30 kg/m^2	48	52	2.42	1.3–4.5	0.005			
Married/cohabitant (n=471)								
No (reference)	32	68	1.0					
Yes	31	69	0.97	0.63–1.49	0.89			
Education (n=470)								
Primary/secondary school (reference)	36	64	1.0		0.26			
High school	33	67	0.87	0.47–1.6	0.65			
College/university <4 yrs	33	67	0.88	0.46–1.7	0.71			
College/university ≥4 yrs	23	77	0.53	0.26–1.09	0.08			
Employment status (n=471)								
Fulltime/student/military service (reference)	27	73	1.0		0.003			
Part-time/homemaker	35	65	1.43	0.78–2.62	0.25			
Retired	24	76	0.86	0.49–1.52	0.6			
Disability benefit/sick leave/unemployed	47	53	2.38	1.44–3.93	0.001			
Comorbidity (n=453)								
No (reference)	26	74	1.0			1.0		
Yes	48	52	2.7	1.77–4.15	<0.001	2.47	1.6–3.81	<0.001
Time since diagnosis (years) (n=472)								
<2 years (reference)	34	66	1.0					
≥2 years	31	69	0.89	0.51–1.54	0.67			
Treatment (n=469)								
One local treatment (reference)	32	68	1.0		0.09			
Two local treatments	19	81	0.5	0.22–1.16	0.11			
Systemic treatment	40	60	1.44	0.65–3.19	0.37			
One local treatment + systemic treatment	34	66	1.11	0.57–2.16	0.75			
Two local treatments + systemic treatment	30	70	0.9	0.43–1.89	0.78			
Disease stage (n=471)								
Localized (reference)	27	73	1.0		0.009	1.0		0.02
Regional	31	69	1.22	0.78–1.93	0.39	1.25	0.77–2.02	0.37
Distant	44	56	2.17	1.32–3.56	0.002	2.17	1.28–3.66	0.004
Daily smoking (n=472)								
No (reference)	29	71	1.0			1.0		
Yes	44	56	1.9	1.13–3.13	0.02	1.79	1.04–3.09	0.04

Numbers may not add up to 472 because of missing data

cOR crude odds ratio, *aOR* adjusted odds ratio. 95% CI, 95% Confidence Interval

[a] Numbers included in the multivariate analyses were 452

Table 4 Prevalence of adopters and factors associated with being an adopter (versus those remain inactive) among inactives before diagnosis (n=503)

	Proportion of adopters%		Unadjusted analyses			Adjusted analyses[a]		
	Yes	No	cOR	95%CI	P	aOR	95%CI	P
All physically inactive at before diagnosis (n=503)	22	78						
N	111	392						
Diagnosis (n=503)								
Lymphoma (reference)	19	81	1.0		0.53			
Testicle	18	82	0.97	0.44–2.16	0.94			
Breast	24	76	1.39	0.75–2.58	0.29			
Gynecological (cervix and ovarian)	27	73	1.56	0.84–2.91	0.16			
Prostate	20	80	1.06	0.53–2.15	0.86			
Age (years) (n=503)								
Middle-aged adult 45–64 (reference)	24	76	1.0		0.08			
Young adult <45 years	27	73	1.15	0.69–1.93	0.58			
Older adults ≥65	16	84	0.6	0.36–1.02	0.06			
BMI (n=480)								
Healthy <25 kg/m^2 (reference)	23	77	1.0		0.48			
Overweight 25–29.9 kg/m^2	25	75	1.11	0.7–1.77	0.65			
Obese ≥30 kg/m^2	18	82	0.75	0.4–1.42	0.38			
Married/cohabitant (n=503)								
No (reference)	25	75	1.0					
Yes	21	79	0.83	0.51–1.36	0.47			
Education (n=502)								
Primary/secondary school (reference)	16	84	1.0		0.04	1.0		0.04
High school	19	81	1.22	0.65–2.31	0.54	1.22	0.65–2.31	0.54
College/university <4 yrs	27	73	1.94	0.97–3.86	0.06	1.94	0.97–3.86	0.06
College/university ≥4 yrs	31	69	2.29	1.13–4.63	0.02	2.29	1.13–4.63	0.02
Employment status (n=503)								
Fulltime/student/military service (reference)	26	74	1.0		0.1			
Part-time/homemaker	27	73	1.09	0.61–1.97	0.77			
Retired	17	83	0.59	0.34–1.02	0.06			
Disability benefit/sick leave/unemployed	17	83	0.58	0.3–1.12	0.10			
Comorbidity (n=492)								
No (reference)	24	76	1.0					
Yes	17	83	0.63	0.39–1.04	0.07			
Time since diagnosis (years) (n=503)								
<2 years (reference)	23	77	1.0					
≥2 years	22	78	1.07	0.70–1.64	0.74			
Treatment (n=501)								
One local treatment (reference)	22	78	1.0		0.11			
Two local treatments	16	84	0.66	0.30–1.45	0.31			
Systemic treatment	12	88	0.46	0.17–1.24	0.13			
One local treatment + systemic treatment	26	74	1.21	0.65–2.24	0.56			
Two local treatments + systemic treatment	27	73	1.28	0.67–2.46	0.45			
Disease stage (n=501)								
Localized (reference)	24	76	1.0		0.21			
Regional	23	77	0.95	0.59–1.53	0.83			
Distant	15	85	0.57	0.3–1.07	0.08			
Daily smoking (n=500)								
No (reference)	24	76	1.0					
Yes	15	85	0.57	0.3–1.06	0.08			

Numbers may not add up to 503 because of missing data

cOR crude odds ratio, *aOR* adjusted odds ratio. 95% CI, 95% Confidence Interval

[a] Numbers included in the multivariate analyses were 502

databases which enhanced the correctness of the data compared to self-report.

Our study might be limited by the possibility of selection bias given the response rate of only 51%. Unfortunately, information about the non-responders was not available. There is a chance that participants completing the questionnaire were those with a particular interest in PA, and thus more physically active than the non-respondents, leading to a relatively high prevalence of physically active cancer survivors. Nevertheless, similar limitations would also affect other studies regarding cancer survivors' LPA [17–20]. Moreover, we have to be aware of the weakness of self-reported information and that individuals tend to overestimate their actual LPA and intensity compared with objective measurements [33]. A recent report from The Norwegian Directorate of Health shows that only about half of the self-reported physically actives were confirmed physically active with objective measures [34]. A frequent gap between objective and subjective reporting of LPA is thus evident. Recall bias could also be a source of error. Finally, the cross-sectional design does not allow causal inference on associations between the independent variables and PA. Further, prospective studies following the changes in LPA across the cancer experience should be explored.

Contrary to our expectations and previous findings [17–20], our results show a relatively high prevalence of cancer survivors meeting exercise guidelines. Except for the possible above mentioned selection bias or an over-reporting of LPA, another explanation could be that Norwegian cancer survivors are more physically active than reported from Northern-America and Australia [17–20]. Other Norwegian studies showed that survivors of Hodgkins lymphoma and testicular cancer had a higher LPA compared to the general population [35, 36].

Unexpectedly, there were only 3% more relapsers than adopters in total. In contrast, Karvinen and colleagues [37] found that twice as many relapsed than adopted among bladder cancer survivors. Additionally, 68% of the participants in the Canadian study were inactive both before diagnosis and after treatment, which is much higher than in the present study. This could probably be due to unavoidable inter-study variations (age, type of cancer, culture etc.).

Consistent with our hypothesis and previous findings, low age, healthy weight, high education, absence of comorbidity and a non-smoking life style were associated with being physically active after treatment [23–27]. Contrary to our hypothesis, no association between being physically active and treatment or disease stage was observed in the multivariable analysis which indicates that these medical factors were of less importance.

The present study suggests that being a relapser is associated with comorbidity and thus that individuals with more comorbidities may be in particular need of post-treatment assistance with physical activity in order to regain maximal health. This finding is in accordance with Coups et al. who found that lung cancer survivors with more comorbidities were more likely to become sedentary after treatment [38]. As expected, we observed an association between disease stage and a decrease in LPA. Somewhat this is in line with Lynch and colleagues who reported an association between having received adjuvant therapy (chemotherapy and/or radiotherapy) and a decrease in LPA [26]. It is reasonable to assume that treatment could be linked to the extension of the disease. Not surprisingly, our results indicate that being an adopter is associated with higher education. Approximately half of the adopters had higher education, whereas only one third of the persistently inactives had higher education. People with high education probably acknowledged post-treatment health benefits of PA, and for some the cancer diagnosis may have positively influenced upon a subsequent healthy behavior. In the literature this is described as a 'teachable moment' that may play an important role in guiding survivors toward a life style that improve overall health [39].

In conclusion, the present study indicates that less than half of the cancer survivors were physically active after treatment. Approximately three quarters of the cancer survivors remained stable in their LPA, whereas the remaining quarter changed their LPA with about half of them in a negative direction. Overall, the findings indicate a more positive trend than expected. Demographic and medical variables as age, weight, education, comorbidity, disease stage and smoking can help identify cancer survivors at risk of physical inactivity after treatment.

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Conflicts of Interest We state that there are no potential conflicts of interest in this study.

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