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

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 ‘gynaecological 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/m² | 445 (48)       |
| Overweight 25–29.9 kg/m² | 350 (37) |
| Obese ≥30 kg/m²  | 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 relapers 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 \( \geq 4 \) 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
Table 2 Prevalence of physically active cancer survivors after treatment and factors associated with being physically active (versus being inactive) (n=975)

| Physically active% | Unadjusted analyses | Adjusted analyses<sup>a</sup> |
|--------------------|---------------------|-------------------------------|
|                    | Yes | No | cOR | 95%CI | P    | cOR | 95%CI | P    |
| All (n=975)        |     |    |     |       |      |     |       |      |
| N                  | 434 | 541|     |       |      |     |       |      |
| Diagnosis (n=975)  |     |    |     |       |      |     |       |      |
| Lymphoma (reference) | 42  | 58 |     | 1.0   | 0.68 |     | 1.0   | 0.03 |
| Testicle           | 47  | 53 | 1.25| 0.82–1.89 | 0.30 | 1.25| 0.80–1.93 | 0.31 |
| Breast             | 47  | 53 | 1.24| 0.87–1.77 | 0.24 | 1.24| 0.85–1.75 | 0.25 |
| Gynecological (cervix and ovarian) | 42  | 58 |     | 1.01 | 0.69–1.46 | 0.98 | 1.01 | 0.69–1.45 | 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 | 1.08| 0.80–1.45 | 0.58 |
| Older adult ≥65    | 38  | 62 | 0.73| 0.53–0.99 | 0.049 | 0.73| 0.52–0.98 | 0.037 |
| BMI (n=934)        |     |    |     |       |      |     |       |      |
| Healthy <25 kg/m² (reference) | 51  | 49 | 1.0 | <0.001 | 1.0 | <0.001 |
| Overweight 25-29.9 kg/m² | 43  | 57 | 0.75| 0.57–0.99 | 0.046 | 0.75| 0.54–0.98 | 0.03 |
| Obese ≥30 kg/m²    | 30  | 70 | 0.42| 0.31–0.69 | <0.001 | 0.42| 0.30–0.71 | <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 | <0.001 |
| 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 | 1.84| 1.20–2.77 | 0.007 |
| College/university ≥4 yrs | 55  | 45 | 2.4 | 1.54–3.73 | <0.001 | 2.4 | 1.26–3.33 | 0.004 |
| Employment status (n=974) |     |    |     |       |      |     |       |      |
| Fulltime/student/military service (reference) | 50  | 50 | 1.0 |       |      |     |       |      |
| 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 |       |      |     |       |      |
| Yes                | 33  | 67 | 0.53| 0.39–0.7 | <0.001 | 0.53| 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 |       | 0.4 |     |       |      |
| 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 | 0.58| 0.36–0.78 | 0.001 |

Numbers may not add up to 975 because of missing data

<sup>a</sup>cOR crude odds ratio, aOR adjusted odds ratio. 95% CI, 95% Confidence Interval

<sup>a</sup>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<sup>a</sup> |
|--------------------------------|--------------------------|---------------------|-------------------------------|
|                                | 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/m² (reference)  | 28  | 72 | 1.0 |       | 0.02 |     |       |    |
| Overweight 25–29.9 kg/m²       | 33  | 67 | 1.26| 0.82–1.95 | 0.3 |     |       |    |
| Obese ≥30 kg/m²                | 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 |       |     |     |       |    |
| 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 |       |     |     |       |    |
| 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

<sup>cOR</sup> crude odds ratio, <sup>aOR</sup> adjusted odds ratio. 95% CI, 95% Confidence Interval

<sup>a</sup>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/m² (reference) | 23  | 77  | 1.0 | 0.48  |     |     |       |     |
| Overweight 25–29.9 kg/m² | 25  | 75  | 1.11| 0.7–1.77 | 0.65 |     |       |     |
| Obese ≥30 kg/m²          | 18  | 82  | 0.75| 0.4–1.42 | 0.38 |     |       |     |
| Married/cohabitant (n=503) | 25  | 75  | 1.0 |       |     |     |       |     |
| No (reference)           | 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) | 23  | 77  | 1.0 |       |     |     |       |     |
| <2 years (reference)     | 22  | 78  | 1.07| 0.7–1.64 | 0.74 |     |       |     |
| ≥2 years                 |     |     |     |       |     |     |       |     |
| Treatment (n=501)        |     |     |     |       |     |     |       |     |
| One local treatment (reference) | 22  | 78  | 1.0 |       |     |     |       |     |
| Two local treatments     | 16  | 84  | 0.66| 0.3–1.45 | 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

aNumbers 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 Coup 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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References
1. Engholm G, Ferlay J, Christensen N, Bray F, Gjerstorff ML, Klint A, et al. NORDCAN—a Nordic tool for cancer information, planning, quality control and research. Acta Oncol. 2010;49:725–36.
2. Cancer Registry of Norway. Cancer in Norway 2008–Cancer incidence, mortality, survival and prevalence in Norway 2009. Ref Type: Report.
3. Horner MJ, Ries LAG, Krapcho M, Neyman N, Aminou R, Howlader N et al. SEER Cancer Statistics Review 1975–2006. National Cancer Institute. Ref Type: Electronic Citation. Available from: http://seer.cancer.gov/csr/1975_2006/. 11-02-2009.
4. Minton O, Stone P. How common is fatigue in disease-free breast cancer survivors? A systematic review of the literature. Breast Cancer Res Treat. 2008;112:5–13.
5. Ness KK, Wall MM, Oakes JM, Robison LL, Gurney JG. Physical performance limitations and participation restrictions among cancer survivors: a population-based study. Ann Epidemiol. 2006;16:197–205.
6. Peuckmann V, Ekholm O, Rasmussen NK, Groenvold M, Christiansen P, Moller S, et al. Chronic pain and other sequelae in long-term breast cancer survivors: nationwide survey in Denmark. Eur J Pain. 2009;13:478–85.
7. Diamond TH, Bucci J, Kersley JH, Aslan P, Lynch WB, Bryant C. Osteoporosis and spinal fractures in men with prostate cancer: risk factors and effects of androgen deprivation therapy. J Urol. 2004;172:529–32.
8. Smith MR. Changes in fat and lean body mass during androgen-deprivation therapy for prostate cancer. Urology. 2004;63:742–5.
9. Tichelli A, Socie G. Considerations for adult cancer survivors. Hematology Am Soc Hematol Educ Program 2005; 516–22.
10. Yeh ET, Bickford CL. Cardiovascular complications of cancer therapy: incidence, pathogenesis, diagnosis, and management. J Am Coll Cardiol. 2009;53:2231–47.
11. Pedersen BK, Saltin B. Evidence for prescribing exercise as therapy in chronic disease. Scand J Med Sci Sports. 2006;16 Suppl 1:3–63.
12. Speck RM, Courneya KS, Masse LC, Duval S, Schmitz KH. An update of controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. J Cancer Surviv. 2010;4:87–100.
13. Conn VS, Hafdahl AR, Porock DC, McDaniel R, Nielsen PJ. A meta-analysis of exercise interventions among people treated for cancer. Support Care Cancer. 2006;14:699–712.
14. McNeely ML, Campbell KL, Rowe BH, Klassen TP, Mackey JR, Courneya KS. Effects of exercise on breast cancer patients and survivors: a systematic review and meta-analysis. CMAJ. 2006;175:34–41.
15. Holick CN, Newcomb PA, Trembath-Dietz A, Titus-Ernstoff L, Bersch AJ, Stampfer MJ, et al. Physical activity and survival after diagnosis of invasive breast cancer. Cancer Epidemiol Biomarkers Prev. 2008;17:379–86.
16. Pierce JP, Stefanick ML, Flatt SW, Natarajan L, Sternfeld B, Madlensky L, et al. Greater survival after breast cancer in physically active women with high vegetable-fruit intake regardless of obesity. J Clin Oncol. 2007;25:2345–51.
17. Stevinson C, Faught W, Steed H, Tonkin K, Ladha AB, Vallance JK, et al. Physical activity and public health. A recommendation from the centers for disease control and prevention and the American College of Sports Medicine. JAMA. 1995;273:402–7.
18. Bellizzi KM, Rowland JH, Arora NK, Hamilton AS, Miller MF, Aziz NM. Physical activity and quality of life in adult survivors of non-Hodgkin's lymphoma. J Clin Oncol. 2009;27:960–6.
19. Coups EJ, Park BJ, Feinstein MB, Steingart RM, Egleston BL, Wilson DJ, et al. Correlates of physical activity among lung cancer survivors. Psychooncology. 2009;18:395–404.
20. Hong S, Bardwell WA, Natarajan L, Flatt SW, Rock CL, Newman VA, et al. Correlates of physical activity level in breast cancer survivors participating in the Women's Healthy Eating and Living (WHEL) Study. Breast Cancer Res Treat. 2007;101:225–32.
21. Lynch BM, Cerin E, Newman B, Owen N. Physical activity, activity change, and their correlates in a population-based sample of colorectal cancer survivors. Ann Behav Med. 2007;34:135–43.
22. Stevinson C, Tonkin K, Capstick V, Schepansky A, Ladha AB, Vallance JK, et al. A population-based study of the determinants of physical activity in ovarian cancer survivors. J Phys Act Health. 2009;6:339–46.
23. Blanchard CM, Denniston MM, Baker F, Ainsworth SR, Courneya KS, Hann DM, et al. Do adults change their lifestyle behaviors after a cancer diagnosis? Am J Health Behav. 2003;27:246–50.
24. Irwin ML, Crumley D, Miettinen A, Bernstein L, Baumgartner R, Gilliland FD, et al. Physical activity levels before and after a diagnosis of breast carcinoma: the Health, Eating, Activity, and Lifestyle (HEAL) study. Cancer. 2003;97:1746–57.
25. Godin G, Jobin J, Bouillon J. Assessment of leisure time exercise behavior by self-report: a concurrent validity study. Can J Public Health. 1986;77:359–62.
26. Jacobs DR, Ainsworth BE, Hartman TJ, Leon AS. A simultaneous evaluation of 10 commonly used physical activity questionnaires. Med Sci Sports Exerc. 1993;25:81–91.
27. Guillemin F, Bombardier C, Beaton D. Cross-cultural adaptation of health-related quality of life measures: literature review and proposed guidelines. J Clin Epidemiol. 1993;46:1417–32.
28. Troiano RP. Large-scale applications of accelerometers: new frontiers in new questions. Med Sci Sports Exerc. 2007;39:1501.
29. Anderssen SA, Hansen BH, Kolle E, Steene-Johannessen J, Borsheim E, Holme I et al. Physical activity among adults and elderly in Norway. Norwegian Directorate of Health 2009. Ref Type: Report.
30. Oldervoll LM, Loge JH, Kaasa S, Lydersen S, Hjermsstad MJ, Thorsen L, et al. Physical activity in Hodgkin's lymphoma survivors with and without chronic fatigue compared with the general population—a cross-sectional study. BMC Cancer. 2007;7:210.
31. Thorsen L, Nystad W, Dahl O, Klepp O, Brennes RM, Wist E, et al. The level of physical activity in long-term survivors of testicular cancer. Eur J Cancer. 2003;39:1216–21.
32. Karvinen KH, Courneya KS, North S, Venner P. Associations between exercise and quality of life in bladder cancer survivors: a population-based study. Cancer Epidemiol Biomarkers Prev. 2007;16:984–90.
33. Coups EJ, Park BJ, Feinstein MB, Steingart RM, Egleston BL, Wilson DJ, et al. Physical activity among lung cancer survivors: changes across the cancer trajectory and associations with quality of life. Cancer Epidemiol Biomarkers Prev. 2009;18:664–72.
34. Demark-Wahnefried W, Aziz NM, Rowland JH, Pinto BM. Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. J Clin Oncol. 2005;23:5814–30.