EUROPEAN JOURNAL OF CANCER 48 (2012) 297–304

Available at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.ejconline.com

Physical activity in a German breast cancer patient cohort: One-year trends and characteristics associated with change in activity level

Christina Huy [a], *Martina E. Schmidt* [a], *Alina Vrieling* [b], *Jenny Chang-Claude* [b], *Karen Steindorf* [a,*]

[a] *Unit of Environmental Epidemiology, German Cancer Research Centre, Im Neuenheimer Feld 280, D-69120 Heidelberg, Germany*
[b] *Division of Cancer Epidemiology, German Cancer Research Centre, Im Neuenheimer Feld 280, D-69120 Heidelberg, Germany*

ARTICLE INFO

Article history:
Available online 14 September 2011

Keywords:
Adjuvant therapy
Breast cancer
Physical activity
Regression analysis

ABSTRACT

Background: Physical activity (PA) is increasingly discussed as concomitant therapy after breast cancer diagnosis and can add to the alleviation of therapy- and disease-related symptoms. The objectives of this study were to describe PA behaviour in the course of breast cancer and to identify factors associated with change in PA.

Methods: 1,067 German postmenopausal breast cancer patients were asked about their PA behaviour before breast cancer diagnosis, during therapy and 1 year after surgery. MET-hours per week (MET = metabolic equivalent) were calculated based on quantitative information about walking, bicycling for transportation purposes and sports by multiplying the average hours per week spent at each activity with an individual intensity score. Factors associated with change in MET·h/week in the course of breast cancer were identified using multiple linear regression.

Results: Median PA decreased significantly during therapy from 36 to 14 MET·h/week ($p < .001$). Patients treated with chemo- and/or radiotherapy had a stronger decline in PA compared to patients without adjuvant therapy or those treated only with hormones (adjusted $\beta = -9.73$ to -13.54). The presence of medical risk factors ($\beta = -5.56$) was also associated with a decrease of PA during therapy. In contrast, participation in rehabilitation ($\beta = 7.62$) was associated with an increase of PA after therapy.

Conclusion: In the light of the drastic decline in PA during therapy, programs promoting PA seem obligatory for all breast cancer patients. Patients treated with chemo- and/or radiotherapy and those with medical risk factors should particularly be assisted in reaching recommended activity levels by targeted interventions during and after therapy.

1. Introduction

Breast cancer is the most frequent type of cancer in women with about 1.2 million new cases in the world per year. In Germany, 58,000 women were diagnosed with breast cancer in 2006 which corresponds to 29.3% of all female cancer cases.[1] Despite increasing incidence – in particular in postmenopausal women – mortality has declined since the

* *Corresponding author:* Tel.: +49 6221 42 2351; fax: +49 6221 42 2229.
E-mail address: k.steindorf@dkfz-heidelberg.de (K. Steindorf).
0959-8049/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ejca.2011.08.005

1990s. This has led to an increasing number of women who are living with a history of breast cancer.

A lack of physical activity (PA) is one of several modifiable risk factors for breast cancer.[2] PA is also increasingly discussed as a supporting factor during adjuvant therapy. It may add to the alleviation of therapy- and disease-related symptoms and health problems that occur after breast cancer diagnosis and that often last for years. Thus, PA can help to reduce physical decline, to improve cardiorespiratory and muscular fitness, to reduce the frequently appearing fatigue symptom and to increase physical performance and quality of life in cancer patients.[3–7] Furthermore, PA plays an important role in the prevention of other health problems in postmenopausal women in general, like cardiovascular diseases, hypertension, obesity and osteoporosis.[8] First observational studies also suggest improved overall survival and reduced rates of breast cancer relapse in association with PA.[9,10] Even cancer patients undergoing burdening treatments are advised to avoid inactivity.[11]

Thus far, there is only a paucity of studies on PA behaviour in breast cancer patients during the course of the disease. These studies were mainly conducted in the United States of America, Canada and Australia,[12–24] some of them were cross-sectional only, and measurement of PA was very heterogeneous. However, particularly due to the increasing number of breast cancer patients and survivors, such studies have great potential, e.g. for investigating the need for interventions. The present study aims to describe PA behaviour during the first year after diagnosis in German breast cancer patients, and to identify factors associated with change in PA.

2. Patients and methods

2.1. Study setting

The MARIE/MARIEplus study is a multicentre population-based patient cohort study which was carried out in two regions in Germany. Patients aged 50–75 years and diagnosed between 2001 and 2005 with primary invasive breast cancer or carcinoma *in situ* were included in the study. All patients had undergone mastectomy or lumpectomy. Out of 5,969 eligible subjects who were invited to participate, 3,919 (65.7%) completed baseline assessment (MARIE study: 2002–2005). Out of these, 2,542 (64.9%) also participated in the telephone interview at follow-up (MARIEplus study: 2009–2010). Data presented here are from postmenopausal patients in the Rhine–Neckar–Karlsruhe region who completed both assessments (n = 1,067).

The MARIE/MARIEplus study has been approved by the ethics committee of the University of Heidelberg. All subjects gave informed consent prior to participation in the study. Baseline data was assessed in standardised personal interviews with a median time lag of 2.2 months after breast cancer surgery (interquartile range, IQR = 7 months). Follow-up assessment was done with computer-assisted telephone interviews 5.4 years (IQR = 1.5 years) after surgery. Further details about the MARIE study have been published previously[25] and are available at the study website (http://www.marie-studie.de).

2.2. Measures

2.2.1. Physical activity

PA was retrospectively assessed at baseline for the prediagnostic periods 30–49 years and 50+ years (until diagnosis) with an interviewer-administered questionnaire.[26] Retrospective PA assessments at follow-up referred to the periods during breast cancer therapy and 1 year after surgery. The period during breast cancer therapy corresponds to the acute therapy phase for patients treated with chemo and/or radiotherapy, or to the first 3 months after surgery for patients treated only with hormones. For all periods, patients were asked to provide information about their average amount of different physical activities during a typical week. Splitting this typical week into weekdays and weekend, the total number of hours spent walking and bicycling for transportation purposes was assessed. Patients were further asked to list their sports activities performed during the selected periods including average duration and frequency. MET-hours per week (MET h/week; MET = metabolic equivalent) were calculated by multiplying the average hours per week spent at each activity with an individual intensity score (e.g. walking: 4.0 MET; bicycling: 6.0 MET; jogging and swimming: each 7.0 MET).[27] Total leisure-time PA was then calculated individually for each period by summing up MET·h/week for walking, bicycling and sports.

We also evaluated adherence to PA guidelines using the following cut points: (a) 30 min moderate activities (3–6 MET) on 5 days/week or 20 min vigorous activities (>6 MET) on 3 days/week according to the guideline of the American College of Sports Medicine/American Heart Association (ACSM/AHA)[28]; (b) 60 min moderate or 30 min vigorous activities per day according to the guideline of the World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR).[29]

Changes in total leisure time PA were determined by calculating (a) the difference between PA level during therapy and at age 50+ (change during therapy: therapy – prediagnosis), (b) the difference between PA level 1 year after surgery and during therapy (change after therapy: 1 year after surgery – therapy), and (c) the difference between PA level 1 year after surgery and at age 50+ (overall change during the whole course of the disease: 1 year after surgery – prediagnosis).

2.2.2. Breast cancer-related variables

Several breast cancer-related variables were assessed through patient records, e.g. tumour stage, type of surgery, axilla lymph node dissection and type of therapy. Furthermore, participation in rehabilitation after surgery was assessed within the interviews.

2.2.3. Other patient-related variables

We also assessed a broad range of other patient-related variables for the period before breast cancer diagnosis. Body mass index (BMI) was calculated based on self-reported height and weight. Additionally, waist–hip ratio (WHR) was calculated based on waist and hip circumference measured by the interviewer. Date of birth and existence of a partnership were self-reported, and educational level was determined based on an additive index on highest graduation and vocational training.

Patients were asked if they had ever been told by a doctor to have any cardiovascular diseases (angina pectoris,

myocardial infarction, stroke, peripheral arterial occlusive disease), orthopaedic diseases (inflammatory joint or spine disease, arthritis, osteoarthritis, rheumatism, osteoporosis), other chronic diseases (lung, thyroid, liver, bowel, bladder/kidney), or medical risk factors (hypertension, diabetes mellitus). We also assessed the smoking status and classified the patients as smokers (regular or occasional smokers) or non-smokers. Patients were further asked to report the amount of different alcoholic beverages they consumed during the time before breast cancer diagnosis and we derived the total amount of absolute alcohol (g) per day from this information. To classify patients according to their drinking behaviour, we used a cut point of 10 g alcohol per day which is the upper limit for safe alcohol consumption for women.[30]

2.3. Statistical analysis

We evaluated the temporal course of PA in MET·h/week during the course of breast cancer using descriptive methods. Statistical significance of change was assessed with Friedman test, considering the dependence of the data. To assess the associations between change in total leisure-time PA and clinical, social and behavioural characteristics, analyses were performed using the Wilcoxon–Mann–Whitney and Kruskal–Wallis test, respectively. Subsequently, multiple linear regressions were performed. All independent variables were entered into the regression models simultaneously; thus, the effect of a predictor was statistically adjusted for all the other potential predictors. The impact of missing observations was investigated by applying multiple imputation techniques for the regression analyses ($n = 10$ imputations).

Data analysis was done with SAS 9.1 [SAS Institute Inc., Cary, USA]. A two-sided alpha level of $p < .05$ was used for all statistical tests. Although we performed multiple testing we did not correct for multiple comparisons given the exploratory nature of our analysis.

3. Results

3.1. Sample characteristics

Most patients were diagnosed with breast cancer stage I (46.3%) or IIa (28.0%). Of all cases, 62.0% were invasive ductal carcinomas. 75.5% and 24.5% of patients had undergone lumpectomy and mastectomy, respectively. In the majority of patients (84.7%) axillary lymph nodes had been dissected. Patients were mainly treated with radiotherapy (45.5%) or a combination of chemo- and radiotherapy (38.3%), independent from treatment with hormones, and 70.7% participated in rehabilitation. Patients had a mean age of 63.5 years ($SD = 5.5$) at baseline and were mainly German citizens (98.2%). Mean BMI and WHR were 26.3 kg/m^2 ($SD = 4.5$) and 0.84 ($SD = .06$), respectively. Patients were mainly living together with a partner (75.2%) and had a basic educational level (61.2% with low education). Patients had a median of two other chronic diseases besides breast cancer at baseline, the most frequent of which were orthopaedic diseases (56.4%). 44.8% of patients had medical risk factors such as hypertension or diabetes, 12.7% had cardiovascular diseases and 47.9% had other chronic internal diseases. 23.8% consumed >10 g alcohol per day, and 14.5% of patients smoked at baseline (Table 1).

3.2. Physical activity in the course of breast cancer

As presented in Fig. 1, there was a slight decline in total leisure-time MET·h/week from age 30–49 to age 50+ until breast cancer diagnosis. During the time between prediagnosis and 1 year after surgery, the course of total leisure-time PA was V-shaped. The course of PA was similar for almost all subgroups of PA by clinical, social and behavioural characteristics (data not shown). Overall, median leisure-time PA level decreased from 36.2 MET·h/week before diagnosis to 14.0 MET·h/week during therapy and increased up to 34.0 MET·h/week 1 year after surgery ($p < .001$). During therapy, MET·h/week for walking, bicycling and sports, separately, all decreased significantly (all $p < .001$). While level of walking increased from 12 MET·h/week during therapy to 20 MET·h/week 1 year after surgery, levels for bicycling and sports remained at a median of 0 MET·h/week during therapy and 1 year after surgery.

Adherence to PA guidelines differed significantly in the course of breast cancer. Proportions for adherence to the ACSM/AHA guideline before diagnosis, during therapy and 1 year after surgery were: 86.2%, 61.0% and 85.1% ($p < .001$). Fewer patients reached the cut point of the WCRF/AICR guideline during these points of time: 56.2%, 27.4% and 56.8% ($p < .001$). For all periods, mainly moderate activities contributed to reaching the cut points. Vigorous activities accounted for only 4.9% of all activities during therapy and for about 10% before diagnosis and 1 year after surgery.

3.3. Changes in physical activity and determinants of change in the course of breast cancer

3.3.1. Changes in physical activity

Median change in total leisure-time PA during therapy was −17.8 ($IQR = 34.7$), increase after therapy was 14.0 ($IQR = 31.3$), and overall change from prediagnostic period to 1 year after surgery was 0.0 MET·h/week ($IQR = 42.6$). Table 1 presents the changes in PA in the course of breast cancer by baseline characteristics.

On a univariate basis, we observed several differences in the change in PA for patient-related variables, participation in rehabilitation, medical risk factors, and PA level before diagnosis. We observed no differences by other breast cancer- or therapy-related variables, or other clinical or behavioural characteristics (Table 1). Multiple linear regression models were then used to investigate to what extent these variables are relevant predictors for changes in PA or if single correlates disappear after inclusion of other covariates. The results of the adjusted analyses are provided in Table 2.

3.3.2. Associations with breast cancer-related variables

Regression analysis showed that patients treated with chemotherapy, radiotherapy, or both had a stronger decline in PA during therapy and the first 3 months after surgery, respectively, compared to patients without therapy or those treated only with hormones (adjusted β and 95% confidence intervals: $\beta = -9.73$ (−18.55; −0.91) to −13.54 (−21.93; −5.15);

Table 1 – Baseline characteristics and change of leisure-time physical activity (MET·h/week) in the course of breast cancer. Percentage (*n*), median and interquartile range (*IQR*).

		Change during therapy (therapy – prediagnosis)		Change after therapy (1 year after surgery – therapy)		Overall change (1 year after surgery – prediagnosis)	
	% (*n*)	Median change (*IQR*)	*p*	Median change (*IQR*)	*p*	Median change (*IQR*)	*p*
Breast cancer-related variables							
Breast cancer stage			.715		.290		.929
In situ/I	52.8% (536)	−18.3 (37.1)		14.0 (34.1)		−0.1 (42.7)	
IIa to IV	47.2% (480)	−17.5 (33.3)		14.0 (29.0)		−0.2 (40.0)	
Type of surgery			.191		.192		.810
Mastectomy	24.5% (259)	−16.0 (34.1)		12.0 (28.0)		0.0 (39.7)	
Lumpectomy	75.5% (797)	−18.3 (37.4)		14.5 (34.2)		0.0 (42.8)	
Axillary lymph node dissection			.679		.552		.867
Yes	84.7% (894)	−17.6 (34.7)		14.0 (32.0)		0.0 (42.7)	
No	15.3% (162)	−20.0 (37.0)		17.3 (29.3)		−1.7 (41.5)	
Type of adjuvant therapy			.593		.488		.856
No/hormone therapy[a]	10.4% (95)	−18.0 (39.2)		14.0 (32.0)		−0.1 (44.3)	
Chemotherapy[a]	5.8% (53)	−12.0 (33.1)		18.0 (23.0)		0.0 (39.7)	
Radiotherapy[a]	45.5% (414)	−17.9 (38.0)		14.8 (34.3)		0.5 (43.1)	
Chemo- and radiotherapy[a]	38.3% (349)	−17.2 (32.7)		14.0 (28.5)		0.0 (39.0)	
Participation in rehabilitation			.014		<.001		.416
Yes	70.7% (750)	−19.7 (37.7)		16.0 (33.5)		0.0 (44.1)	
No	29.3% (311)	−15.6 (31.7)		10.3 (28.0)		−2.0 (38.3)	
Patient-related variables							
Age at breast cancer surgery			.358		.003		.002
<65 years	62.3% (662)	−17.0 (36.6)		16.0 (32.3)		2.2 (43.8)	
⩾65 years	37.7% (400)	−19.3 (33.6)		12.0 (28.0)		−4.0 (38.1)	
Body mass index			.083		.002		.369
<18.5 kg/m^2	1.2% (13)	−15.9 (31.9)		27.5 (53.0)		11.2 (58.5)	
18.5–<25.0 kg/m^2	42.9% (457)	−18.2 (37.4)		16.0 (33.0)		0.0 (45.1)	
25.0–<30.0 kg/m^2	38.0% (405)	−19.0 (36.8)		15.4 (32.3)		−1.0 (42.2)	
30.0–<35.0 kg/m^2	13.0% (138)	−13.3 (31.6)		12.0 (24.0)		0.0 (37.4)	
35.0–<40.0 kg/m^2	4.2% (45)	−14.0 (35.4)		4.0 (17.3)		−1.6 (22.0)	
⩾40.0 kg/m^2	0.7% (7)	−34.1 (67.4)		8.0 (20.0)		−14.1 (72.0)	
Waist–hip ratio			.002		.014		.149
⩽0.85	58.3% (593)	−20.0 (39.7)		16.0 (30.0)		−1.3 (42.8)	
>0.85	41.7% (424)	−15.5 (32.9)		12.5 (30.0)		0.2 (42.5)	
Living together with a partner			.796		.736		.731
Yes	75.2% (800)	−17.9 (33.8)		14.0 (32.8)		0.0 (41.8)	
No	24.8% (264)	−17.6 (41.5)		14.0 (29.0)		−0.8 (46.2)	
Educational level			.090		.286		.076
Low	61.2% (653)	−18.0 (37.3)		12.0 (31.5)		−1.3 (42.7)	
Middle	23.0% (245)	−19.9 (34.0)		16.0 (31.0)		−2.0 (42.6)	
High	15.8% (169)	−15.8 (34.0)		15.0 (33.8)		7.0 (44.0)	
Other clinical characteristics							
Cardiovascular diseases[b]			.334		.687		.117
Yes	12.7% (134)	−19.2 (34.9)		16.0 (28.0)		−3.7 (42.2)	
No	87.3% (923)	−17.5 (35.6)		14.0 (32.8)		0.0 (42.9)	
Orthopaedic diseases[c]			.161		.129		.544
Yes	56.4% (593)	−16.1 (35.1)		14.0 (32.0)		0.0 (40.9)	
No	43.6% (458)	−19.9 (35.6)		15.7 (30.0)		−1.2 (43.6)	
Medical risk factors[d]			.980		.004		.014
Yes	44.8% (478)	−17.4 (32.7)		12.0 (29.9)		−2.2 (37.5)	
No	55.2% (588)	−18.6 (38.9)		16.0 (32.3)		2.0 (50.0)	
Other diseases[e]			.580		.918		.868
Yes	47.9% (508)	−17.9 (37.3)		14.0 (31.7)		−0.5 (40.3)	
No	52.1% (552)	−17.6 (35.1)		14.0 (32.1)		0.0 (44.0)	
Health behaviour							
Smoking			.158		.322		.588
Yes	14.5% (155)	−16.0 (36.0)		12.0 (30.0)		2.0 (45.7)	
No	85.5% (912)	−18.0(36.5)		14.5 (31.6)		−0.5 (42.3)	

Table 1 – (*continued*)

		Change during therapy (therapy – prediagnosis)		Change after therapy (1 year after surgery – therapy)		Overall change (1 year after surgery – prediagnosis)	
	% (*n*)	Median change (*IQR*)	*p*	Median change (*IQR*)	*p*	Median change (*IQR*)	*p*
Alcohol consumption			.750		.784		.748
⩽10 g/day	76.2% (813)	−17.4 (37.0)		14.0 (33.0)		−0.4 (42.5)	
>10 g/day	23.8% (254)	−18.5 (34.5)		14.9 (31.5)		0.0 (41.8)	
PA level before diagnosis			<.001		<.001		<.001
⩽36.2 MET·h/week	50.1% (535)	−6.7 (20.4)		10.5 (25.8)		8.0 (32.5)	
>36.2 MET·h/week	49.9% (532)	−36.7 (25.8)		19.0 (38.8)		−15.0 (54.7)	

[a] With or without hormone therapy at the same time.
[b] Angina pectoris, myocardial infarction, stroke or peripheral arterial occlusive disease.
[c] Inflammatory joint or spine disease, arthritis, osteoarthritis, rheumatism or osteoporosis.
[d] Hypertension or diabetes mellitus.
[e] Chronic disease of lung, thyroid, liver, bowel or bladder/kidney.

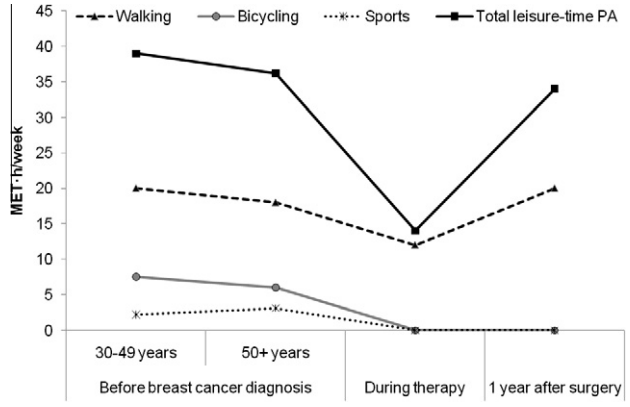

Fig. 1 – Walking, bicycling, sports and total leisure-time physical activity in the course of breast cancer. Median MET·h/week. MET·h/week for walking, bicycling and sports do not add up exactly to total leisure-time PA because median values were used for the presentation of single activities.

all $p < .05$). Overall decline in PA was also greater in patients treated with chemo- ($\beta = -15.41$ (−30.28; −0.55); $p = .042$) or radiotherapy ($\beta = -12.56$ (−24.97; −0.15); $p = .047$). Participation in rehabilitation was positively associated with an increase in PA after breast cancer therapy ($\beta = 7.62$ (2.63; 12.61); $p = .003$; Table 2).

3.3.3. *Associations with patient-related variables*

There was a negative association for age considering overall change in PA after controlling for other covariates ($\beta = -0.66$ (−1.22; −0.10) per year; $p = .020$). We found no significant associations with BMI, WHR, or other patient-related variables in the multiple regression models (Table 2).

3.3.4. *Associations with other clinical characteristics*

Patients with medical risk factors had a stronger decline in PA during therapy compared to those without these conditions ($\beta = -5.56$ (−9.59; −1.53); $p = .007$). The presence of medical risk factors was also a negative predictor for overall change in total leisure-time PA ($\beta = -8.25$ (−14.26; −2.24); $p = .007$). We observed no further significant results for other clinical characteristics (Table 2).

3.3.5. *Associations with health behaviour*

Patients with a higher prediagnostic PA level had a greater decline in PA during therapy ($\beta = -0.77$ (−0.83; −0.72) per MET·h/week; $p < .001$). We also found significant associations for change after therapy and overall change in total leisure-time PA. Smoking and alcohol consumption were not significantly associated with change in PA in adjusted analyses (Table 2).

4. Discussion

4.1. *Principle findings*

This study describes for the first time the course of PA behaviour before diagnosis, during treatment and 1 year after surgery in a large cohort of German breast cancer patients. We observed a significant decrease in total leisure-time PA during breast cancer therapy. Treatment with chemo- and/or radiotherapy, age, presence of medical risk factors and prediagnostic PA level were associated with a decrease in PA in the course of breast cancer. However, participation in rehabilitation was associated with an increase of PA after therapy. These results highlight the need for interventions, especially for vigorous leisure-time activities, and assistance in particular for patients treated with chemo- and/or radiotherapy and those with medical risk factors.

4.2. *Relation to other studies*

In accordance with previous studies, we observed a significant decline of PA during breast cancer therapy.[12,20,23] However, direct comparison with results from other studies is difficult due to differences in the assessment and operationalisation of PA, such as variations in PA domains, assignment

Table 2 – Multiple linear regression models for determinants of change in physical activity (MET·h/week) in the course of breast cancer. Regression coefficients (β) with 95% confidence intervals (CI).

	Change during therapy (therapy – prediagnosis)		Change after therapy (1 year after surgery – therapy)		Overall change (1 year after surgery – prediagnosis)	
	β (95% CI)	p	β (95% CI)	p	β (95% CI)	p
Breast cancer-related variables						
Breast cancer stage (per TNM class)	−0.28 (−2.13; 1.57)	.764	0.03 (−2.21; 2.16)	.982	−0.31 (−3.07; 2.45)	.827
Type of surgery						
Mastectomy	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Lumpectomy	4.40 (−1.73; 10.52)	.159	2.28 (−4.73; 9.29)	.524	6.68 (−2.36; 15.71)	.147
Axillary lymph node dissection						
Yes	−2.68 (−8.00; 2.63)	.323	0.48 (−5.89; 6.85)	.882	−2.20 (−10.12; 5.72)	.586
No	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Type of adjuvant therapy						
No/hormone therapy	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Chemotherapy	−13.14 (−23.14; −3.14)	.010	−2.27 (−13.96; 9.41)	.703	−15.41 (−30.28; −0.55)	.042
Radiotherapy	−13.54 (−21.93; −5.15)	.002	0.98 (−8.43; 10.39)	.838	−12.56 (−24.97; −0.15)	.047
Chemo- and radiotherapy	−9.73 (−18.55; −0.91)	.031	−2.32 (−12.14; 7.51)	.643	−12.05 (−24.93; 0.84)	.067
Participation in rehabilitation						
Yes	−1.42 (−5.57; 2.73)	.503	7.62 (2.63; 12.61)	.003	6.20 (0.01; 12.39)	.050
No	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Patient-related variables						
Age at breast cancer surgery (per year)	−0.23 (−0.60; 0.15)	.232	−0.44 (−0.89; 0.01)	.058	−0.66 (−1.22; −0.10)	.020
Body mass index (per BMI unit)	−0.21 (−0.66; 0.25)	.375	−0.27 (−0.82; 0.28)	.335	−0.48 (−1.16; 0.21)	.171
Waist–hip ratio						
⩽0.85	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
>0.85	3.61 (−0.47; 7.69)	.083	−0.20 (−4.69; 5.09)	.936	3.41 (−2.76; 9.58)	.279
Living together with a partner						
Yes	−0.64 (−5.09; 3.82)	.780	0.03 (−5.38; 5.32)	.991	−0.67 (−7.33; 6.00)	.845
No	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Educational level						
Low	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Middle	2.05 (−2.60; 6.70)	.388	2.37 (−3.22; 7.95)	.406	4.42 (−2.52; 11.36)	.212
High	2.13 (−3.27; 7.53)	.440	2.14 (−4.36; 8.63)	.519	4.27 (−3.79; 12.33)	.300
Other clinical characteristics						
Cardiovascular diseases						
Yes	−5.30 (−10.97; 0.38)	.067	−0.91 (−7.70; 5.89)	.794	−6.20 (−14.67; 2.27)	.151
No	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Orthopaedic diseases						
Yes	0.36 (−3.52; 4.25)	.855	−1.79 (−6.46; 2.87)	.452	−1.43 (−7.24; 4.38)	.629
No	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Medical risk factors						
Yes	−5.56 (−9.59; −1.53)	.007	−2.69 (−7.53; 2.15)	.276	−8.25 (−14.26; −2.24)	.007
No	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Other diseases						
Yes	−3.34 (−7.11; 0.42)	.082	3.34 (−1.20; 7.88)	.149	0.00 (−5.63; 5.63)	.999
No	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Health behaviour						
Smoking						
Yes	−0.48 (−6.11; 5.15)	.867	−2.81 (−9.57; 3.94)	.415	−3.30 (−11.69; 5.10)	.442
No	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
Alcohol consumption						
⩽10 g/day	1.00 (Ref.)	.803	1.00 (Ref.)	.898	1.00 (Ref.)	.787
>10 g/day	−0.56 (−4.97; 3.84)		−0.35 (−5.64; 4.95)		−0.91 (−7.48; 5.67)	
PA level before diagnosis (MET·h/week)	−0.77 (−0.83; −0.72)	<.001	0.24 (0.17; 0.31)	<.001	−0.53 (−0.62; −0.45)	<.001
Intercept	47.71 (18.42; 77.00)	.001	42.05 (6.87; 77.23)	.019	89.77 (46.03; 133.50)	<.0001

Cases were completed with multiple imputation before analysis. All independent variables were entered into the regression models simultaneously.

of MET-values, cut points used for definition of adequate PA level, and adjustment for different variables. Although absolute PA values between the MARIE/MARIEplus study and other studies differ due to methodological considerations, there is concordance for relative change in PA level. A study from the US showed a relative decline of 50% in PA during therapy

(from 18.8 to 9.2 MET·h/week),[23] which is a bit lower than that in the MARIE/MARIEplus study (61%). In both studies, decline was mainly related to decline in vigorous activities, and prediagnostic levels could not be fully reached during follow-up in the overall study population. In contrast, other studies showed that PA reached prediagnostic levels 6 months and 1 year after end of therapy, respectively.[12,16]

In the MARIE/MARIEplus study, adherence rates for PA guidelines were relatively high compared to other studies (ACSM/AHA: 61% during therapy and 85% 1 year after surgery). Other international studies found rates of 15% and 20% during therapy, 25% 6 months after end of therapy, 37% 1 year after diagnosis (only sports),[12,16] as well as 32% (sports/leisure-time PA) and 73% (including housework) 3 years after diagnosis.[21] There were no studies using the WCRF/AICR cut point to compare with. Besides differences in methods, instruments and cut points, one reason for these differing findings might be that day-to-day walking, which mainly contributed to reaching the cut points, was included in our analyses. The detailed PA assessment in the MARIE/MARIEplus study might have resulted in a better estimation of PA compared to other studies. Another explanation could be that cut points of the PA guidelines have been developed in the US. Therefore, they may reflect PA behaviour in the US (where inactivity is more prevalent) and nations with comparable infrastructure, but might be less appropriate for German samples due to different infrastructures and habits.

Results from previous work on the association between PA and type of breast cancer therapy were inconclusive. Studies showed both negative and lacking associations in particular with chemotherapy.[12,19,20] The MARIE/MARIEplus study supports a negative association between PA and chemo- and/or radiotherapy, showing a larger decline of PA in patients treated with these therapies compared to those with hormone therapy alone or no systemic therapy at all. Our finding of a negative association between prediagnostic PA level and change in PA during therapy points towards a regression-to-the-mean effect which was also observed in previous studies.[20,23]

4.3. *Strengths and limitations of the study*

This is the first study on PA in German breast cancer patients and it contributes to a better understanding of the determinants of change in PA in the course of the disease. Strengths of the study are in particular its large sample size, which enabled adjustment for numerous covariates, the detailed assessment of PA including walking, bicycling and sports activities and the inclusion of multiple points of time before and after breast cancer diagnosis. Furthermore, the MARIE/MARIEplus study is one of the few population-based cohort studies which followed up breast cancer patients to investigate the change of health behaviour during the course of the disease.

However, the PA assessment for the different points of time was not carried out in a prospective longitudinal design but done retrospectively. Our data are also liable to other limitations inherent in self-reported data, which might result in over- or underestimation of PA and other variables like BMI or diseases other than breast cancer. Furthermore, there might be a bias due to systematic loss-to-follow-up, which means that patients with bad health status (or those who died during follow-up) were not included in the follow-up assessment. Hence, the sample might consist of those patients who are sufficiently fit to participate in such a study. However, in case of such a healthy survivor bias real PA in the overall population of breast cancer patients would be even lower than shown in our study. Thus, our data describe a "best case scenario", emphasising the need for interventions. Although our results may not be fully generalisable to other international settings, they nonetheless warrant careful consideration given the absence of other European work examining PA trends in breast cancer patients during the course of disease.

5. Conclusion

In the light of the increasing evidence for positive health effects of PA during the breast cancer experience and the drastic decline of PA during breast cancer therapy, there is a need for programs promoting exercise and PA for the entire breast cancer patient population. Patients treated with chemo- and/or radiotherapy and those with medical risk factors should receive particular support in maximising their activity level by targeted interventions during and after therapy. Increase of participation in rehabilitation might also help to increase PA level. In the long run, increase of PA in breast cancer patients and survivors could result in positive physical and psychological effects for this group.

Conflict of interest statement

None declared.

Acknowledgements

The MARIE/MARIEplus study is funded by the Deutsche Krebshilfe e. V. [Grant No. 70-2892-BR I and 108523/108419], the Hamburg Cancer Society, the German Cancer Research Centre, and the German Federal Ministry for Education and Research [Grant No. 01KH0402]. We thank U. Eilber, C. Krieg, S. Behrens and R. Birr for data collection and management.

REFERENCES

1. Ferlay J, Bray F, Pisani P, Parkin DM. *GLOBOCAN 2002: Cancer incidence, mortality and prevalence worldwide. IARC CancerBase No. 5 (version 2.0)*. Lyon: IARC Press; 2004.
2. Monninkhof EM, Elias SG, Vlems FA, et al. Physical activity and breast cancer: a systematic review. *Epidemiology* 2007;**18**:137–57.
3. Schmitz KH, Holtzman J, Courneya KS, et al. Controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. *Cancer Epidemiol Biomarkers Prev* 2005;**14**:1588–95.
4. McNeely ML, Campbell KL, Rowe BH, et al. Effects of exercise on breast cancer patients and survivors: a systematic review and meta-analysis. *CMAJ* 2006;**175**:34–41.
5. Courneya KS. Exercise in cancer survivors: an overview of research. *Med Sci Sports Exerc* 2003;**35**:1846–52.

6. Mock V, Pickett M, Ropka ME, et al. Fatigue and quality of life outcomes of exercise during cancer treatment. *Cancer Pract* 2001;**9**:119–27.
7. Valenti M, Porzio G, Aielli F, et al. Physical exercise and quality of life in breast cancer survivors. *Int J Med Sci* 2008;**5**:24–8.
8. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. *CMAJ* 2006;**174**:801–9.
9. Holmes MD, Chen WY, Feskanich D, Kroenke CH, Colditz GA. Physical activity and survival after breast cancer diagnosis. *JAMA* 2005;**293**:2479–86.
10. Irwin ML, Smith AW, McTiernan A, et al. Influence of pre- and postdiagnosis physical activity on mortality in breast cancer survivors: the Health, Eating, Activity, and Lifestyle study. *J Clin Oncol* 2008;**26**:3958–64.
11. Schmitz KH, Courneya KS, Matthews C, et al. American College of Sports Medicine roundtable on exercise guidelines for cancer survivors. *Med Sci Sports Exerc* 2010;**42**:1409–26.
12. Andrykowski MA, Beacham AO, Jacobsen PB. Prospective, longitudinal study of leisure-time exercise in women with early-stage breast cancer. *Cancer Epidemiol Biomarkers Prev* 2007;**16**:430–8.
13. Blanchard CM, Cokkinides V, Courneya KS, et al. A comparison of physical activity of posttreatment breast cancer survivors and noncancer controls. *Behav Med* 2003;**28**:140–9.
14. Caan B, Sternfeld B, Gunderson E, et al. Life After Cancer Epidemiology (LACE) Study: a cohort of early stage breast cancer survivors (United States). *Cancer Causes Control* 2005;**16**:545–56.
15. Courneya KS, Katzmarzyk PT, Bacon E. Physical activity and obesity in Canadian cancer survivors: population-based estimates from the 2005 Canadian Community Health Survey. *Cancer* 2008;**112**:2475–82.
16. Emery CF, Yang HC, Frierson GM, Peterson LJ, Suh S. Determinants of physical activity among women treated for breast cancer in a 5-year longitudinal follow-up investigation. *Psychooncology* 2009;**18**:377–86.
17. Gho SA, Steele JR, Munro BJ. Is bra discomfort a barrier to exercise for breast cancer patients? *Support Care Cancer* 2009; doi:10.1007/s00520-009-0707-2.
18. Harrison S, Hayes SC, Newman B. Level of physical activity and characteristics associated with change following breast cancer diagnosis and treatment. *Psychooncology* 2009;**18**:387–94.
19. Hong S, Bardwell WA, Natarajan L, 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.
20. Irwin ML, Crumley D, McTiernan A, 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.
21. Irwin ML, McTiernan A, Bernstein L, et al. Physical activity levels among breast cancer survivors. *Med Sci Sports Exerc* 2004;**36**:1484–91.
22. Lindsey AM, Waltman N, Gross G, Ott CD, Twiss J. Cancer risk-reduction behaviors of breast cancer survivors. *West J Nurs Res* 2004;**26**:872–90.
23. Littman AJ, Tang MT, Rossing MA. Longitudinal study of recreational physical activity in breast cancer survivors. *J Cancer Surviv* 2010;**4**:119–27.
24. Lynch BM, Dunstan DW, Healy GN, et al. Objectively measured physical activity and sedentary time of breast cancer survivors, and associations with adiposity: findings from NHANES (2003–2006). *Cancer Causes Control* 2010;**21**:283–8.
25. Schmidt ME, Steindorf K, Mutschelknauss E, et al. Physical activity and postmenopausal breast cancer: effect modification by breast cancer subtypes and effective periods in life. *Cancer Epidemiol Biomarkers Prev* 2008;**17**:3402–10.
26. Schmidt ME, Slanger T, Chang-Claude J, Wahrendorf J, Steindorf K. Evaluation of a short retrospective questionnaire for physical activity in women. *Eur J Epidemiol* 2006;**21**:575–85.
27. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc* 2000;**32**:S498–504.
28. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation* 2007;**116**:1081–93.
29. World Cancer Research Fund /American Institute for Cancer Research. *Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Second expert report*. Washington: AICR; 2007.
30. Burger M, Brönstrup A, Pietrzik K. *Alkoholkonsum und Krankheiten [Alcohol consumption and diseases]. Reports of the Federal Ministry for Health, vol. 134*. Baden-Baden: Nomos; 2000.