Impact and Determinants of Structural Barriers on Physical Activity in People with Cancer

Johanna Depenbusch1,2 · Joachim Wiskemann3 · Alexander Haussmann1 · Angeliki Tsiouris3,4 · Laura Schmidt5 · Nadine Ungar5 · Monika Sieverding5 · Karen Steindorf1

Accepted: 15 July 2021 / Published online: 22 September 2021
© The Author(s) 2021

Abstract

Background. A better understanding of the role of structural barriers for physical activity (PA) after a cancer diagnosis could help to increase PA among people with cancer. Thus, the present study aimed to identify determinants of structural barriers to PA in people with cancer and investigate the association between structural barriers and insufficient post-diagnosis PA, taking different PA change patterns into account.

Methods. A total of 1299 people with breast, prostate, or colorectal cancer completed a questionnaire assessing their socio-demographic and medical characteristics, pre- and post-diagnosis PA, and perceived PA impediment by seven structural barriers. Regression analyses were used to investigate determinants of the perception of structural barriers and to examine the association between structural barriers and insufficient post-diagnosis PA, also with regard to different pre-diagnosis PA levels.

Results. Overall 30–60% of participants indicated to feel impeded by structural barriers. The analyses revealed a younger age, higher BMI, lower educational level, no current work activity, co-morbidities, and lacking physicians’ exercise counseling as significant determinants of the perception of structural barriers. Individuals reporting stronger impediments by structural barriers were significantly less likely to be meeting PA guidelines post-diagnosis, particularly those with sufficient pre-diagnosis PA levels.

Conclusions. The study highlights the need for tailored PA programs for people with cancer as well as for more guidance and support in overcoming structural barriers to improve PA behavior.

The study has been registered under NCT02678832 at clinicaltrials.gov on February 10th 2016.

Keywords Cancer · Exercise oncology · Impediment · Physical activity · Structural barriers
Introduction

Physical activity (PA) is considered as one of the most effective self-management strategies for people with cancer [1]. As numerous studies have documented positive effects on treatment-related side effects like reduced fatigue and increased quality of life [2, 3] and further indicated an association with decreased risks of cancer recurrence and cancer-specific mortality [4–6], PA is playing an increasingly important role during and after cancer treatment. Accordingly, current guidelines recommend that people with cancer should perform at least 30 min of moderate-intensity aerobic activity three times per week and 20 to 30 min of resistance exercises twice per week [7].

Although the awareness for PA seems to increase and recent studies have reported encouragingly high numbers of sufficiently active people with cancer [8], there is still a considerably large number of individuals who remain insufficiently active or decrease their PA after the diagnosis [9, 10]. To successfully develop and implement interventions aiming to improve PA behavior among people with cancer, it appears crucial to identify barriers that prevent them from performing PA. In this context, Hefferon et al. defined psychological barriers like lack of motivation and fear, physical and disease-related barriers like treatment-related side effects and co-morbidities, and structural barriers like missing access to exercise facilities as the three main themes for not engaging in PA [11]. While previous research has mainly focused on physical and disease-related barriers and identified treatment-related side effects, fatigue, pain or other health-related problems as the most frequently reported barriers to PA across different cancer types [12–15], the role of structural barriers has only scarcely been investigated so far.

Of note, a few studies have suggested that structural barriers might be less prevalent than other types of barriers but nevertheless affect PA behavior most strongly. One study investigating personal, social, and structural barriers indicated that although personal barriers were reported more frequently, structural barriers, i.e., a missing exercise partner and lack of place to perform PA as well as missing access to a gym or equipment and insecurity about what to do, were significantly associated with fewer PA minutes among people with breast and prostate cancer [16]. Results of a study among colorectal cancer patients revealed that structural barriers had the strongest effect on whether individuals met PA guidelines post-diagnosis although they were the least salient barriers [17].

However, these studies have mainly looked at environmental factors, whereas a systematic assessment of different kinds of structural barriers is still lacking. Given the suggested impediment by structural barriers for PA among people with cancer, it appears worthwhile to gain a more differentiated understanding. Aiming to increase PA after a cancer diagnosis by alleviating the perception of structural barriers, it firstly seems important to determine, which individuals perceive structural barriers as particularly impeding for their PA. Some studies have indicated that the perception of overall barriers differs between different cancer types [16, 18] and might be increased among younger individuals with lower educational levels and a higher body mass index (BMI) [15], but potential determinants for structural barriers have been neglected so far. Besides socio-demographic and medical characteristics, it seems likely that physicians’ exercise counseling plays a role for the perception of structural barriers as it could counteract a lack of information and knowledge about suitable exercise programs [19]. Furthermore, the association between different structural barriers and post-diagnosis PA needs to be investigated in more detail. Previous research has shown that individuals who perceive structural barriers are less likely to be meeting PA guidelines after the diagnosis [17]. However, insufficient PA post-diagnosis can result from two different PA change patterns: Becoming insufficiently active, i.e., decrease of PA to insufficient levels among individuals, who were meeting PA guidelines before the diagnosis, vs. remaining insufficiently active, i.e., maintenance of insufficient PA levels among individuals, who were not meeting PA before the diagnosis. Considering this distinction might enable a more specific targeting of PA interventions and therefore help to counteract insufficient PA after a cancer diagnosis.

Thus, the present study aimed to (a) identify to what extent socio-demographic and medical characteristics and physicians’ exercise counseling explained the perception of structural barriers as impeding for PA, (b) investigate whether the perception of structural barriers was associated with insufficient post-diagnosis PA, and (c) explore whether the proposed association between structural barriers and insufficient post-diagnosis PA applied equally to the two possible PA change patterns, i.e. becoming vs. remaining insufficiently active.

Method

Design and Participants

The present cross-sectional study was part of the large-scale Momentum project Heidelberg. The survey was conducted between January 2017 and May 2018 and aimed to assess social-cognitive norms regarding physical activity among people with cancer. The study was targeted at individuals who were diagnosed with breast, prostate, or
All information were provided by participants as self-report in a paper-pencil or congruent online survey. Socio-demographic and medical variables comprised age, sex, height, and weight for the calculation of the BMI, educational level, current work status, cancer type, date of latest diagnosis, treatment type, and status and a list of co-morbidities. Physicians’ exercise counseling was assessed in accordance to the 5A framework [20]. Participants were asked to indicate which of the five counseling steps (Assess, Advise, Agree, Assist, and Arrange follow-up) their physician had covered. Based on this, a weighted sum score (5A score) was computed which considered the number as well as profundness of the single counseling steps [21].

For PA assessment, a modified version of the Godin-Shepard Leisure-Time Physical Activity Questionnaire [22] was used, asking how many minutes of light, moderate, and vigorous-intensity PA were performed on average per week before the cancer diagnosis and in the last week. Moderate-to-vigorous PA (MVPA) minutes were calculated as moderate-intensity PA minutes plus two times vigorous-intensity PA minutes. Participants were classified as not meeting PA guidelines (0–149 min MVPA/week) or meeting PA guidelines (≥ 150 min MVPA/week) pre- and post-diagnosis. Based on this, two change patterns for insufficient post-diagnosis PA were defined: (1) becoming insufficiently active, i.e., meeting PA guidelines pre- but not post-diagnosis, and (2) remaining insufficiently active, i.e., not meeting PA guidelines pre- and post-diagnosis.

Items for perception of structural barriers for PA were generated based on our previous qualitative and quantitative study among HCP [33, 40] and pre-tested in a pilot study among 85 people with cancer. Participants were asked to rate to what extent the following 7 factors impeded their PA on a 4-point Likert scale from 0 “not at all” to 3 “very strongly”: (1) lack of information material regarding PA for people with cancer, (2) lack of PA offers specifically for people with cancer, (3) lack of PA offers overall, (4) lack of possibility to clarify if one is medically suitable for PA, (5) lack of a contact person who is specialized in exercise oncology counseling and treatment, (6) lack of therapeutic programs that are reimbursed by health care insurances, and (7) lack of parks, walking, running and cycling paths or public pools in the neighborhood [23]. To compute the number of perceived barriers, the variables were dichotomized as 0 “not at all” vs. 1 “slightly, strongly or very strongly” and values were summed up across all barriers.

Statistical Analyses

Descriptive statistics were used to determine socio-demographic and medical characteristics of the study population as well as exercise counseling, MVPA, and structural barrier variables. Separate linear regression analyses were performed to identify determinants of the perception of each structural barrier and the number of perceived barriers. To investigate the impact of structural barriers on insufficient post-diagnosis PA, odds ratios (OR) with 95% confidence intervals (CI) were estimated in logistic regression analyses. The seven barriers and the number of barriers were evaluated as interval-scaled predictors independently of each other in separate regression models. The analyses were adjusted for age and sex as well as factors that were found to be significant predictors of post-diagnosis PA in previous studies among the same sample, i.e., BMI, educational level, cancer type, time since diagnosis, co-morbidities, pre-diagnosis MVPA, and 5A score [8, 21]. To further explore differences in the proposed association of structural barriers and insufficient post-diagnosis PA between the two possible change patterns, the sample was split according to whether or not participants were meeting PA guidelines pre-diagnosis. Logistic regression analyses were re-run for each split-sample to determine if structural barriers were associated with (1) becoming insufficiently active among participants who were meeting PA guidelines pre-diagnosis and (2) remaining insufficiently active among participants who were not meeting PA guidelines pre-diagnosis. All statistical analyses were carried out with IBM SPSS version 25. A p < 0.05 was considered statistically significant.

Results

Descriptive Statistics

The recruitment flow of the study is presented in Fig. 1. The overall sample of eligible participants consisted of 1299 people with cancer, of which 631 were diagnosed with breast,

Note that no differentiation was made between aerobic and resistance exercises.
344 with prostate and 324 with colorectal cancer. A total of 754 individuals were female; participants were on average 60.0 years old (SD = 12.5) and 14.9 months post-diagnosis (SD = 7.6). Further descriptive characteristics of the sample are shown in Table 1. Table 2 displays the perceived impediment for PA by structural barriers. Overall, 30 to 58% of participants indicated to feel at least slightly impeded in their PA; the mean number of reported barriers was 2.8 (SD = 2.4). The most frequently reported barrier was “lack of therapeutic programs that are reimbursed by health care insurances” (57.9%), followed by “lack of an expert contact person” (53.2%) and “lack of PA offers specifically for people with cancer” (48.3%) (Fig. 2).

Determinants of the Perception of Structural Barriers

Results of the linear regression analyses indicated that a younger age, lower educational level, and no current work activity were significantly associated with stronger impediments by all structural barriers except “lack of parks, paths or pools in the neighborhood” as well as with a higher number of perceived barriers (all p’s < 0.05) (Table 3). A higher BMI was revealed as a further significant predictor of five of the barriers and a higher overall number of barriers (all p’s < 0.05). With regard to medical factors, people with prostate cancer (p = 0.044) and those who had received radiotherapy (p = 0.007) perceived a lack of PA programs overall as more impeding for their PA; having received radiotherapy was moreover significantly associated with stronger impediments by a lack of possibility for medical clearance for PA (p = 0.005) and a higher number of barriers (p = 0.007). Participants with co-morbidities reported stronger impediments by four of the structural barriers and a higher number of barriers (all p’s < 0.05). Lastly, a less comprehensive exercise counseling was associated with barriers “lack of information material” (p = 0.009), “lack of possibility for medical clearance for PA” (p = 0.015), and “lack of expert contact person” (p = 0.001).

Association of Structural Barriers and Insufficient Post-diagnosis PA

Results of the logistic regression analyses examining the association of perceived structural barriers and insufficient post-diagnosis PA are displayed in Table 4. The analyses revealed that individuals who perceived structural barriers as more impeding for their PA were significantly more likely to be insufficiently active post-diagnosis, above and beyond the effect of established PA determinants. Among all structural barriers, “lack of information material” was most strongly related to insufficient post-diagnosis PA with each increase in level of perceived impediment increasing the likelihood of not meeting PA guidelines post-diagnosis by 38% (CI 1.15; 1.65, p < 0.001). Higher perceived impediments by other structural barriers, except “lack of parks,
paths or pools in the neighborhood,” increased the likelihood of not meeting PA guidelines post-diagnosis by 16–30% (all p’s < 0.05). A higher number of perceived barriers was also significantly associated with insufficient post-diagnosis PA with each additional barrier increasing the likelihood of not meeting PA guidelines post-diagnosis by 14% (CI 1.07; 1.21, p < 0.001).

**Association of Structural Barriers and Change Patterns for Insufficient Post-diagnosis PA**

Investigating the association of structural barriers and insufficient post-diagnosis PA in subgroups defined by whether or not individuals were meeting PA guidelines pre-diagnosis however revealed that the association differed between the two change patterns for insufficient post-diagnosis PA (Table 5). The analyses among participants who were meeting PA guidelines before the diagnosis yielded that those perceiving higher impediment by structural barriers were significantly more likely to become insufficiently active: All except for two barriers increased the likelihood of not meeting PA guidelines post-diagnosis by 20–39% with each increase in level of impediment (all p’s < 0.05). Looking at the number of barriers, each additional perceived barrier was associated with a 16% increase in the likelihood of becoming insufficiently active (CI 1.07; 1.26, p < 0.001). In contrast, none of the structural barriers were significantly associated with the pattern of remaining insufficiently active among previously insufficiently active individuals (all p’s > 0.05).

**Discussion**

In the present study, we investigated the perception of structural barriers for PA among people with breast, prostate, or colorectal cancer by identifying determinants and examining the association of structural barriers and insufficient post-diagnosis PA in terms of different PA change patterns. Overall, 30–60% of participants indicated to perceive impediment for their PA by structural barriers, which was particularly salient among individuals who were younger, currently not working, had a lower educational level, a higher BMI, co-morbidities, and reported less comprehensive exercise counseling by physicians. With regard to post-diagnosis PA, we found that individuals who perceived higher impediments by structural barriers were more likely to be insufficiently active post-diagnosis. However, the association did not apply to participants who remained insufficiently active pre- and post-diagnosis but only to those who were meeting PA guidelines pre-diagnosis and became insufficiently active thereafter.

Only a few studies have investigated the role of structural barriers for PA among people with cancer so far,
thereby mainly focusing on environmental factors \[13, 16, 17\]. Consistent with these studies, minority of individuals perceived a lack of overall PA offers or exercise opportunities in the neighborhood as a barrier to PA in our study. However, the results of our study suggest that beyond this, individuals with cancer seem to perceive structural barriers that relate to a lack of disease-adjusted PA offers and support as much more impeding for their PA with about half of participants indicating that a lack of therapeutic programs reimbursed by health care insurances, a missing contact person who is specialized in exercise oncology counseling and treatment as well as a lack of PA offers specifically designed for people with cancer kept them from performing PA. The latter is in line with findings from a previous study where 52% of participants reported to be unaware of available PA programs \[18\]. The prevalence of this kind of structural barriers points out the desire for more guidance, support, and possibilities to exercise in a setting that is specifically tailored to the individual’s health condition. As previous research regarding facilitators for PA among people with cancer has also yielded preferences for PA programs that are tailored according to individual abilities and disease states \[24–26\], the uptake and adherence to PA after a cancer diagnosis might be enhanced by the development and implementation of individually adjusted PA programs.

We further investigated which individuals, based on their socio-demographic and medical characteristics, perceived structural barriers as particularly impeding for their PA. The analyses yielded a stronger impediment among people with a higher BMI and lower educational levels, which is in line with previous research \[15\]. As these individuals tend to be less inclined to exercise in general \[8, 27, 28\], structural barriers could already influence their intention to initiate PA. In accordance with Romero et al. \[15\], impediment by structural barriers was also higher among younger individuals. Of note, a younger age has previously been shown to be associated with higher post-diagnosis PA levels \[9, 29, 30\]. A possible explanation for the nevertheless stronger perception of structural barriers could be that daily obligations like work or family duties keep younger individuals from searching for possibilities to overcome perceived barriers. With regard to medical determinants, we found that participants with co-morbidities reported higher levels of impediment by structural barriers. This extends previous literature where co-morbidities as such were identified as barriers for PA among people with cancer \[12, 13\]. Physical restrictions and health issues could thus not only pose a challenge to exercise but also lead to more insecurity about the safety of PA, which points out the need for particular guidance on how and where to safely perform PA in consideration of individual health conditions.

### Table 2 Descriptive statistics of perceived structural barriers

| Lack of | Not at all | Slightly | Strongly | Very strongly | Mean, SD |
|---------|-----------|----------|----------|---------------|----------|
| Information material | 679 | 58.8 | 308 | 26.7 | 113 | 9.8 | 54 | 4.7 | 1.60 | 0.85 |
| PA offers for people with cancer | 592 | 51.7 | 283 | 24.7 | 176 | 15.4 | 95 | 8.3 | 1.80 | 0.98 |
| PA offers overall | 793 | 70.2 | 223 | 19.7 | 88 | 7.8 | 26 | 2.3 | 1.42 | 0.73 |
| Possibility for medical clearance | 666 | 58.6 | 276 | 24.3 | 126 | 11.1 | 69 | 5.3 | 1.65 | 0.90 |
| Expert contact person | 533 | 46.8 | 303 | 26.6 | 197 | 17.3 | 105 | 9.2 | 1.89 | 1.00 |
| Reimbursement for PA programs | 482 | 42.1 | 256 | 22.4 | 236 | 20.6 | 170 | 14.9 | 2.08 | 1.10 |
| Parks, paths or pools in neighborhood | 936 | 81.5 | 143 | 12.5 | 44 | 3.8 | 25 | 2.2 | 1.27 | 0.64 |

\(M\) mean, \(SD\) standard deviation, \(PA\) physical activity

\(^{a}\)Based on 4-point Likert Scale with 0 “not at all”; 1 “slightly”; 2 “strongly”; 3 “very strongly”

\(^{b}\)Based on dichotomized barrier variable with 0 “not at all”; 1 “slightly, strongly, very strongly”. \(M=2.8, SD=2.4\)
As expected, the perception of structural barriers was strongly associated with insufficient post-diagnosis PA, which supports the results of a study among people with colorectal cancer [17]. However, while Lynch et al. rather focused on suitable PA facilities and the local environment and calculated an overall score for structural barriers [17], we further specified the contribution of thematically different structural barriers. The results indicated that a lack of information material was most strongly related to insufficient post-diagnosis PA. Providing information material appears as a convenient and time-efficient PA intervention method and the relevance of exercise counseling by HCP as patients’ preferred source of information has been widely acknowledged in the literature [19, 21, 31, 32]. However, given that physicians often do not feel qualified or lack the time to discuss PA [33–35] and additional information material has been revealed as a crucial component of effective exercise counseling [36], it appears necessary to establish and enhance the access to high-quality self-educational material for interested individuals. Our results further indicated that not the local environment but rather a lack of PA offers specifically designed for people with cancer, expert contact persons, and financial reimbursement kept individuals from performing PA. These findings have important practical implications as they do not only highlight the need for suitable exercise programs for people with cancer but also emphasize the relevance of informative communication as well as medical and financial support in this regard.

Considering that previous PA behavior has been shown to be the strongest predictor of post-diagnosis PA [8], we further explored the role of structural barriers as a function of different change patterns for insufficient post-diagnosis PA. Interestingly, the analyses showed that the perception of structural barriers was not significant for the pattern of remaining insufficiently active among individuals who were not meeting PA guidelines pre-diagnosis. On the one hand, this could be explained by a floor effect; i.e., individuals with no pre-diagnosis PA did not face any structural barriers due to their inactivity. On the other hand, other factors such as low intentions and low perceived behavioral control may be stronger predictors for post-diagnosis PA behavior among individuals with low pre-diagnosis PA levels. In contrast, structural barriers seemed to pose a greater challenge for the maintenance of sufficient PA levels in the presence of disease-related issues among previously active individuals. This could explain why individuals who were highly active before the diagnosis tend to show stronger decreases in their PA behavior from pre- to post-diagnosis than those with lower pre-diagnosis

```
Fig. 2 Frequencies of participants perceiving impediment for physical activity (PA) by structural barriers
```

* based on dichotomized barrier variable with 0 ‘not at all’; 1 ‘slightly, strongly, very strongly’
Table 3  Linear regression results on socio-demographic and medical determinants of perceiving structural barriers

|                                | Lack of information material | Lack of PA offers for people with cancer | Lack of PA offers overall | Lack of possibility for medical clearance | Lack of expert contact person | Lack of reimbursement for PA programs | Lack of parks, paths or pools in neighborhood | Number of barriers |
|--------------------------------|-----------------------------|----------------------------------------|---------------------------|------------------------------------------|-------------------------------|-------------------------------------|---------------------------------------------|-------------------|
| Age (per year)                 |                             |                                        |                           |                                          |                               |                                     |                                             |                   |
|                                | -.010          .001         | -.023         < .001                   | -.012         < .001       | -.011         .001                       | -.019         < .001            | -.024         < .001                    | -.003          .236          | -.048          < .001 |
| Sexb                          | -.208         .061         | -.258         .039                      | -.078         .412               | -.051         .666               | -.140         .283                        | -.293         .037                        | -.032          .696                        | -.518          .084 |
| BMI (per 1 kg/m²)              | .015           .010                     | .015         .023                      | .017         < .001               | .004         .515               | .008         .215                        | .017         .019                        | .010          .022                        | .056          < .001 |
| Educational levelc             | -.113         .046         | -.163         .010                      | -.133         .006               | -.187         .002               | -.148         .026                        | -.232         < .001                      | -.032          .445                        | -.481          .002 |
| Current work statusd           | -.136         .046         | -.331         < .001                    | -.149         .010               | -.213         .003               | -.238         .003                        | -.205         .017                        | -.041          .413                        | -.650          < .001 |
| Cancer type                   |                             |                                        |                           |                                          |                               |                                     |                                             |                   |
| Colorectalc                   | .153           .154         | -.023         .842                      | .171           .056               | .036         .745               | .128           .298                        | .057           .670                        | -.024          .758                        | .334           .239 |
| Prostatef                     | .253           .058         | .086         .564                      | .229           .044               | .135         .342               | .260           .097                        | .222           .187                        | -.031          .747                        | .634           .078 |
| Time since diagnosis (per month) | -.005         .171         | .000         .935                      | -.004         .228               | -.005         .207               | -.006         .191                        | .000           .929                        | -.003          .393                        | -.013          .230 |
| Current treatmentd            | .087           .339         | .125         .220                      | .053           .501               | .115         .231               | .160           .134                        | .219           .056                        | .038           .572                        | .462           .059 |
| Chemotherapyh                 | -.029         .658         | .071         .324                      | .021           .701               | .062         .363               | .044           .564                        | -.046          .575                        | .008           .868                        | -.036          .835 |
| Radiotherapyh                 | .038           .547         | .043         .550                      | .147           .007               | .193         .065               | .123           .102                        | .155           .054                        | .075           .111                        | .465           .007 |
| Hormone therapyh              | -.052         .582         | -.067         .532                      | .032           .695               | -.077         .446               | -.107          .337                        | -.151          .206                        | -.017          .810                        | -.341          .217 |
| Co-morbiditiesi               | .074           .202         | .189         .004                      | .087           .081               | .137           .028               | .155           .024                        | .156           .033                        | .046           .279                        | .381           .015 |
| 5A score for PA counselingj   | -.075         .009         | -.041         .210                      | .005           .838               | -.075         .015               | -.117          .001                        | -.015          .682                        | .002           .925                        | -.126          .106 |

aRegression coefficients are displayed as unstandardized beta coefficients
b0: female; 1: male
c0: no degree or (lower-) secondary education degree; 1: diploma qualifying for university or university degree
d0: homemaker, retired, on sick-leave or unemployed; 1: currently working or student
eCancer type, dummy-coded; 0: breast cancer, prostate cancer; 1: colorectal cancer
fCancer type, dummy-coded; 0: breast cancer, colorectal cancer; 1: prostate cancer
gh0: currently not receiving chemo, radio, or hormone therapy; 1: currently receiving chemo, radio, or hormone therapy
i0: never having received this treatment; 1: having received or currently receiving this treatment
j0: no co-morbidities; 1 ≥ 1 co-morbidities
kWeighted sumscore for PA counseling based on 5A framework; higher values indicate more comprehensive counseling
Table 4  Linear regression results on socio-demographic and medical determinants of perceiving structural barriers overall and for each barrier of the target population

| Structural barrier | Per 1 step | Per 1 year | Male | Female | Per 1 kg/m² | Lower | Higher | Per 1 month | Prostate | Time since diagnosis | None | Co-morbidities | Prediagnosis | MVPA | 5A score |
|-------------------|------------|------------|------|--------|------------|-------|--------|-------------|----------|---------------------|------|---------------|-------------|-------|---------|
| Lack of information material | 1.38 (1.15; 1.65) | < .001 | 1.00 (0.98; 1.01) | 0.77 (0.40; 1.43) | 0.73 (0.40; 1.33) | 2.32 (1.40; 3.77) | | | | | | | | | |
| Lack of PA offers for people with cancer | 1.27 (1.12; 1.48) | 0.002 | 0.99 (0.97; 1.01) | 0.74 (0.41; 1.34) | 0.67 (0.40; 1.48) | 1.00 (1.00; 1.01) | | | | | | | | | |
| Lack of PA offers overall | 1.22 (1.12; 1.38) | 0.001 | 0.99 (0.97; 1.01) | 0.74 (0.41; 1.34) | 0.67 (0.40; 1.48) | 1.00 (1.00; 1.01) | | | | | | | | | |
| Lack of possibility for medical clearance | 0.99 (0.82; 1.18) | > .05 | 0.99 (0.97; 1.01) | 0.74 (0.41; 1.34) | 0.67 (0.40; 1.48) | 1.00 (1.00; 1.01) | | | | | | | | | |
| Age | Per 1 year | 1.00 (0.98; 1.01) | 1.00 (0.98; 1.01) | 1.00 (0.98; 1.01) | 1.00 (0.98; 1.01) | | | | | | | | | | |
| Sex | Male | 0.73 (0.40; 1.33) | 0.74 (0.41; 1.34) | 0.67 (0.40; 1.48) | 0.67 (0.40; 1.48) | | | | | | | | | | |
| BMI | Per 1 kg/m² | 1.06 (1.02; 1.09) | 1.06 (1.02; 1.09) | 1.06 (1.02; 1.09) | 1.06 (1.02; 1.09) | | | | | | | | | | |
| Educational level | Lower | 0.67 (0.49; 0.91) | 0.67 (0.49; 0.91) | 0.67 (0.49; 0.91) | 0.67 (0.49; 0.91) | | | | | | | | | | |
| Cancer type | Breast | 2.66 (1.59; 4.54) | < .001 | 2.74 (1.64; 4.55) | < .001 | | | | | | | | | | |
| Time since diagnosis | Per 1 month | 0.97 (0.95; 0.99) | < .001 | 1.00 (1.00; 1.00) | < .001 | | | | | | | | | | |
| Pre-diagnosis MVPA | 0–149 min/week | 6.50 (4.73; 8.95) | < .001 | 6.08 (4.43; 8.34) | < .001 | | | | | | | | | | |
| 5A score | Per 1 step | 0.72 (0.61; 0.85) | < .001 | 0.70 (0.60; 0.82) | < .001 | | | | | | | | | | |

Note: OR = Odds Ratio, CI = Confidence Interval, p = p-value.
| Structural barrier | Per 1 step | OR  | CI     | p    | OR  | CI     | p    | OR  | CI     | p    |
|-------------------|-----------|-----|--------|------|-----|--------|------|-----|--------|------|
| Lack of expert contact person | 1.30 | (1.12; 1.51) | .001 | 1.16 | (1.00; 1.33) | .043 | 1.21 | (0.95; 1.55) | .119 | 1.14 | (1.07; 1.21) | <.001 |
| Lack of reimbursement for PA programs | 1.00 | (0.98; 1.03) | .821 | 1.00 | (0.98; 1.01) | .907 | 1.00 | (0.98; 1.01) | .591 | 1.00 | (0.99; 1.02) | .987 |
| Lack of parks, paths or pools in neighborhood | 0.67 | (0.37; 1.23) | .194 | 0.68 | (0.38; 1.25) | .214 | 0.70 | (0.39; 1.26) | .237 | 0.75 | (0.41; 1.36) | .341 |
| Number of barriers | 1.06 | (1.02; 1.09) | .001 | 1.06 | (1.02; 1.09) | .001 | 1.06 | (1.02; 1.09) | .001 | 1.05 | (1.02; 1.08) | .004 |

**Model for barrier: Lack of expert contact person**
- **OR**: 1.30 (95% CI 1.12; 1.51), p < .001
- **OR**: 1.16 (95% CI 1.00; 1.33), p = .043
- **OR**: 1.21 (95% CI 0.95; 1.55), p = .119
- **OR**: 1.14 (95% CI 1.07; 1.21), p < .001

| Age | Per 1 year | 1.00 | (0.98; 1.03) | .821 | 1.00 | (0.98; 1.01) | .907 | 1.00 | (0.98; 1.01) | .591 | 1.00 | (0.99; 1.02) | .987 |
|-----|------------|------|---------------|------|-----|---------------|------|-----|---------------|------|-----|---------------|------|
| Sex | Female | Reference | Reference | 1.00 | (0.98; 1.01) | .907 | 1.00 | (0.98; 1.01) | .591 | 1.00 | (0.99; 1.02) | .987 |
|     | Male     | 0.67   | (0.37; 1.23) | .194 | 0.68 | (0.38; 1.25) | .214 | 0.70 | (0.39; 1.26) | .237 | 0.75 | (0.41; 1.36) | .341 |
| BMI | Per 1 kg/m² | 1.06  | (1.02; 1.09) | .001 | 1.06 | (1.02; 1.09) | .001 | 1.06 | (1.02; 1.09) | .001 | 1.05 | (1.02; 1.08) | .004 |
| Educational level | Lower | Reference | Reference | 1.06 | (1.02; 1.09) | .001 | 1.06 | (1.02; 1.09) | .001 | 1.05 | (1.02; 1.08) | .004 |
|      | Higher   | 0.66   | (0.49; 0.89) | .007 | 0.68 | (0.51; 0.93) | .14  | 0.66 | (0.49; 0.90) | .008 | 0.68 | (0.50; 0.92) | .013 |
| Cancer type | Breast | Reference | Reference | 2.79 | (1.66; 4.70) | <.001 | 2.82 | (1.69; 4.72) | <.001 | 2.64 | (1.59; 4.39) | <.001 | 2.63 | (1.58; 4.38) | <.001 |
|    | Colorectal | 3.21 | (1.58; 6.50) | .001 | 3.08 | (1.54; 6.18) | .002 | 2.94 | (1.47; 5.86) | .002 | 2.88 | (1.44; 5.77) | .003 |
|    | Prostate | 2.64 | (1.59; 4.39) | <.001 | 2.88 | (1.44; 5.77) | .003 | 2.63 | (1.58; 4.38) | <.001 | 2.63 | (1.58; 4.38) | <.001 |
| Time since diagnosis | Per 1 month | 0.97 | (0.95; 0.99) | .001 | 0.96 | (0.94; 0.98) | <.001 | 0.96 | (0.94; 0.98) | <.001 | 0.96 | (0.95; 0.98) | <.001 |
| Co-morbidities | None | Reference | Reference | 1.44 | (1.05; 1.97) | .023 | 1.41 | (1.03; 1.92) | .033 | 1.45 | (1.06; 1.98) | .020 | 1.36 | (1.00; 1.86) | .053 |
|    | ≥1 | Reference | Reference | 1.45 | (1.06; 1.98) | .020 | 1.36 | (1.00; 1.86) | .053 | 1.36 | (1.00; 1.86) | .053 |
| Pre-diagnosis MVPA | 0-149 min/week | 6.37 | (4.63; 8.78) | <.001 | 6.21 | (4.53; 8.53) | <.001 | 6.19 | (4.52; 8.50) | <.001 | 6.38 | (4.66; 8.75) | <.001 |
|    | ≥150 min/week | 1.44 | (1.05; 1.97) | .023 | 1.41 | (1.03; 1.92) | .033 | 1.45 | (1.06; 1.98) | .020 | 1.36 | (1.00; 1.86) | .053 |
| 5A score | Per 1 step | 0.72 | (0.61; 0.85) | <.001 | 0.69 | (0.59; 0.82) | <.001 | 0.71 | (0.60; 0.83) | <.001 | 0.70 | (0.60; 0.83) | <.001 |

**Model for barrier: Lack of reimbursement for PA programs**
- **OR**: 1.00 (95% CI 0.98; 1.01), p = .907
- **OR**: 1.00 (95% CI 0.98; 1.01), p = .591
- **OR**: 0.70 (95% CI 0.39; 1.26), p = .237
- **OR**: 0.75 (95% CI 0.41; 1.36), p = .341

**Model for barrier: Lack of parks, paths or pools in neighborhood**
- **OR**: 1.06 (95% CI 1.02; 1.09), p = .001
- **OR**: 1.06 (95% CI 1.02; 1.09), p = .001
- **OR**: 1.05 (95% CI 1.02; 1.08), p = .004

**Model for number of barriers**
- **OR**: 1.06 (95% CI 1.02; 1.09), p = .001
- **OR**: 1.06 (95% CI 1.02; 1.09), p = .001
- **OR**: 1.05 (95% CI 1.02; 1.08), p = .004

**OR** odds ratio, CI 95% confidence interval, PA physical activity, MVPA moderate-to-vigorous physical activity

Separate regression models for each structural barrier. Dependent variable “insufficient post-diagnosis PA”, i.e., not meeting PA guidelines of 150 min MVPA per week. Bold values indicate p < .05

*aStructural barrier as indicated in column heading; impediment for PA measured on a scale from 0 “not at all” to 3 “very strongly”; higher values indicate higher perceived impediment for PA

*bLower: no degree or (lower-) secondary education degree; Higher: diploma qualifying for university or university degree

*cWeighted sumscore for PA counseling based on 5A framework, higher values indicate more comprehensive counseling
PA levels [37, 38]. Thus, it appears important to acknowledge that particularly previously active individuals, who are usually more likely to continue pursuing PA after the diagnosis, seem to be impeded in their PA by structural barriers and hence in need of support to overcome these barriers.

**Strengths and Limitations**

To our knowledge, this is the first study to comprehensively investigate determinants and the impact of structural barriers on post-diagnosis PA in people with cancer and the results reveal important new insights. Nevertheless, some limitations have to be considered. Our study comprised a large sample, but is missing detailed data on socioeconomic status of participants and lacking variance in terms of receipt of surgery, both factors that have been shown to be relevant for PA behavior among people with cancer and could be meaningful predictors of the perception of structural barriers [15, 39]. Data on PA was collected as retrospective self-report and could therefore be biased. Further, the assessment of PA barriers might not be extensive. While participants were asked to rate the perception of seven different structural barriers, other potential barriers to PA like health-related, social, or personal factors have not been analyzed in terms of impediment for PA. Therefore, it is not possible to compare the contribution of structural barriers to other barrier themes, which would be an interesting research question for future studies. Further, it would be interesting for future research to investigate how structural barriers interact with psychological variables like intentions or attitudes towards PA in their effect on post-diagnosis PA. Finally, the cross-sectional design of our study does not allow causal inferences.

**Conclusion and Implications**

In conclusion, our study emphasizes the contribution of different structural barriers to insufficient post-diagnosis PA among people with breast, prostate, and colorectal cancer. The analyses revealed differences in the perception of structural barriers with regard to individuals’ socio-demographic and medical characteristics, which are relevant for a more specific targeting of PA interventions. The associations of almost all structural barriers with insufficient post-diagnosis PA, particularly among individuals who were sufficiently active before the diagnosis, do not only highlight the need for the implementation of individually adjusted PA programs but further point out the importance of improvements in patient education as well as medical guidance and financial support with regard to PA after a cancer diagnosis.

**Acknowledgements** This study was part of the Momentum Project that has been supported by a grant from the German Cancer Aid (Grant No. 110512, 110551, and 111223). We thank Fiona Rupprecht, Lena Radke, Nina Immel, Sara Kuru, Sophie Madlinger, Elisa Ebler, and Xenia Peukert for their help in the recruitment, coding procedure, and data management.
Funding Open Access funding enabled and organized by Projekt DEAL.

Declarations

Research Involving Human and Animal Participants All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Ethical Approval The study obtained ethical approval the ethics commission of the Faculty of Behavioral and Cultural Studies of the University of Heidelberg [AZ Siev 2015/1-1, AZ Siev 2016/1-2].

Informed Consent Informed consent was obtained from all individual participants included in the study. The authors declare that they have full control of all primary data and that they agree to allow the journal to review our data.

Conflict of Interest The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

1. Demark-Wahnefried W, Rogers LQ, Alfiano CM, et al. Practical clinical interventions for diet, physical activity, and weight control in cancer survivors. CA Cancer J Clin. 2015;65(3):167–89.
2. Buffart LM, Kalter J, Sweegers MG, et al. Effects and moderators of exercise on quality of life and physical function in patients with cancer: an individual patient data meta-analysis of 34 RCTs. Cancer Treat Rev. 2017;52:91–104.
3. Segal R, Zwaal C, Green E, Tomasone JR, Loblaw A, Petrella T. Exercise for people with cancer: a systematic review. Curr Oncol. 2017;24(4):e290–315.
4. Cormie P, Zopfi EM, Zhang X, Schmitz KH. The impact of exercise on cancer mortality, recurrence, and treatment-related adverse effects. Epidemiol Rev. 2017;39(1):71–92.
5. Patel AV, Friedenreich CM, Moore SC, et al. American College of Sports Medicine roundtable report on physical activity, sedentary behavior, and cancer prevention and control. Med Sci Sports Exerc. 2019;51(11):2991–402.
6. Mcdonagh A, Friedenreich CM, Katzmazryk PT, et al. Physical activity in cancer prevention and survival: a systematic review. Med Sci Sports Exerc. 2019;51(6):1252–61.
7. Campbell KL, Winters-Stone KM, Wiseman J, et al. Exercise guidelines for cancer survivors: consensus statement from international multidisciplinary roundtable. Med Sci Sports Exerc. 2019;51(11):2375–90.
8. Steindorf K, Depenbusch J, Haussmann A, et al. Change patterns and determinants of physical activity differ between breast, prostate, and colorectal cancer patients. Support Care Cancer. 2020;28(7):3207–18.
9. Eng L, Pringle D, Su J, et al. Patterns, perceptions, and perceived barriers to physical activity in adult cancer survivors. Support Care Cancer. 2018;26(11):3755–63.
10. Thraen-Borowski KM, Gennuso KP, Cadmus-Bertram L. Accelerometer-derived physical activity and sedentary time by cancer type in the United States. PloS One. 2017;12(8):e0182554.
11. Hefferon K, Murphy H, McLeod J, Mutrie N, Campbell A. Understanding barriers to exercise implementation 5-year post-breast cancer diagnosis: a large-scale qualitative study. Health Educ Res. 2013;28(5):843–56.
12. Fisher A, Wardle J, Beeken RJ, Croker H, Williams K, Grimmett C. Perceived barriers and benefits to physical activity in colorectal cancer patients. Support Care Cancer. 2016;24(2):903–10.
13. Blaney JM, Lowe-Strong A, Rankin-Watt J, Campbell A, Gracey JH. Cancer survivors’ exercise barriers, facilitators and preferences in the context of fatigue, quality of life and physical activity participation: a questionnaire-survey. Psychooncology. 2013;22(1):186–94.
14. Clifford BK, Mizrahi D, Sandler CX, et al. Barriers and facilitators of exercise experienced by cancer survivors: a mixed methods systematic review. Support Care Cancer. 2018;26(3):685–700.
15. Romero SAD, Brown JC, Bauml JM, et al. Barriers to physical activity: a study of academic and community cancer survivors with pain. J Cancer Surviv. 2018;12(6):744–52.
16. Ottenbacher AJ, Day RS, Taylor WC, et al. Exercise among breast and prostate cancer survivors—what are their barriers? J Cancer Surviv. 2011;5(4):413–9.
17. Lynch BM, Owen N, Hawkes AL, Aitken JF. Perceived barriers to physical activity for colorectal cancer survivors. Support Care Cancer. 2010;18(6):729–34.
18. Fernandez S, Franklin J, Amlani N, DeMilleVille C, Lawson D, Smith J. Physical activity and cancer: a cross-sectional study on the barriers and facilitators to exercise during cancer treatment. Can Oncol Nurs J. 2015;25(1):37–48.
19. Schmitz KH, Campbell AM, Stuiver MM, et al. Exercise is medicine in oncology: Engaging clinicians to help patients move through cancer. CA Cancer J Clin. 2019;69(6):468–84.
20. Estabrooks PA, Glasgow RE, Dzewaltowski DA. Physical activity promotion through primary care. JAMA. 2003;289(22):2913–6.
21. Depenbusch J, Haussmann A, Tsouri A, et al. The association between physicians’ exercise counseling and physical activity in patients with cancer: Which roles do patients’ satisfaction and previous physical activity levels play? Psychooncology. 2020;29(11):1856–63.
22. Godin G. The Godin–Shephard Leisure-Time Physical Activity Questionnaire. Health Fit J Can. 2011;14(1):18–22.
23. Spittaels H, Verloigne M, Gidlow C, et al. Measuring physical activity-related environmental factors: reliability and predictive validity of the European environmental questionnaire ALPHA. Int J Behav Nutr Phys Act. 2010;7(1):48.
24. Avancini A, Tregnado D, Rigatti L, et al. Factors influencing physical activity in cancer patients during oncological treatments: a qualitative study. Integ Cancer Ther. 2020;19:15347354209711365.
25. Blaney JM, Lowe-Strong A, Rankin J, Campbell A, Allen J, Gracey J. The cancer rehabilitation journey: barriers to and facilitators of exercise among patients with cancer-related fatigue. Phys Ther. 2010;90(8):1135–47.
26. Elshahat S, Treanor C, Donnelly M. Factors influencing physical activity participation among people living with or beyond cancer: a systematic scoping review. Int J Behav Nutr Phys Act. 2021;18(1):50.
27. Schmidt ME, Wiskemann J, Ulrich CM, Schneeweiss A, Steindorf K. Self-reported physical activity behavior of breast cancer survivors during and after adjuvant therapy: 12 months follow-up of two randomized exercise intervention trials. Acta Oncol. 2017;56(4):618–27.
28. Forbes CC, Blanchard CM, Mummery WK, Courneya KS. A comparison of physical activity correlates across breast, prostate and colorectal cancer survivors in Nova Scotia. Canada Support Care Cancer. 2014;22(4):891–903.
29. Lynch BM, Boyle T, Winkler E, Occleston J, Courneya KS, Vallance JK. Patterns and correlates of accelerometer-assessed physical activity and sedentary time among colon cancer survivors. Cancer Causes Control. 2016;27(1):59–68.
30. Kampshoff CS, Stacey F, Short CE, et al. Demographic, clinical, psychosocial, and environmental correlates of objectively assessed physical activity among breast cancer survivors. Support Care Cancer. 2016;24(8):3333–42.
31. Hardcastle SJ, Cohen PA. Effective physical activity promotion to survivors of cancer is likely to be home based and to require oncologist participation. J Clin Oncol. 2017;35(32):3635–7.
32. O’Leary KA, Estabrooks CA, Olson K, Cumming C. Information acquisition for women facing surgical treatment for breast cancer: influencing factors and selected outcomes. Patient Educ Couns. 2007;69(1–3):5–19.
33. Haussmann A, Ungar N, Gabrian M, et al. Are healthcare professionals being left in the lurch? The role of structural barriers and information resources to promote physical activity to cancer patients. Support Care Cancer. 2018;26(12):4087–96.
34. Ligibel JA, Jones LW, Brewster AM, et al. Oncologists’ attitudes and practice of addressing diet, physical activity, and weight management with patients with cancer: findings of an ASCO survey of the oncology workforce. J Oncol Pract. 2019;15(6):e520–e528.
35. Nadler M, Bainbridge D, Tomasono J, Cheifetz O, Juergens RA, Sussman J. Oncology care provider perspectives on exercise promotion in people with cancer: an examination of knowledge, practices, barriers, and facilitators. Support Care Cancer. 2017;25(7):2297–304.
36. Park JH, Lee J, Oh M, et al. The effect of oncologists’ exercise recommendations on the level of exercise and quality of life in survivors of breast and colorectal cancer: a randomized controlled trial. Cancer. 2015;121(16):2740–8.
37. Huy C, Schmidt ME, Vrieling A, Chang-Claude J, Steindorf K. Physical activity in a German breast cancer patient cohort: one-year trends and characteristics associated with change in activity level. Eur J Cancer. 2012;48(3):297–304.
38. Fassier P, Zelek L, Partula V, et al. Variations of physical activity and sedentary behavior between before and after cancer diagnosis: results from the prospective population-based NutriNet-Sante cohort. Medicine. 2016;95(40):e4629.
39. Naik H, Qiu X, Brown MC, et al. Socioeconomic status and lifestyle behaviours in cancer survivors: smoking and physical activity. Curr Oncol. 2016;23(6):e546–55.
40. Haussmann A, Gabrian M, Ungar N, Jooß S, Wiskemann J, Sieverding M, Steindorf K. What hinders healthcare professionals in promoting physical activity towards cancer patients? The influencing role of healthcare professionals’ concerns, perceived patient characteristics and perceived structural factors. Eur J Cancer Care. 2018;27(4):e12853

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.