

## Original article

# Identification and prediction of physical activity trajectories in women treated for breast cancer



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## ABSTRACT

**Purpose:** In this study, we aimed to identify trajectories of physical activity in a cohort of women over a 1-year period after treatment for breast cancer. We also examined factors that could predict trajectory group membership.

**Methods:** We collected data from 199 women using questionnaires at baseline (mean = 3.46 months after treatment), and 3, 6, 9, and 12 months thereafter.

**Results:** Based on semiparametric group-based modeling, there were five trajectories: consistently inactive, decreasing levels, inactive with increasing levels, somewhat active, and consistently sufficiently active. Based on logistic regression analysis, women who reported higher levels of depressive symptoms and fatigue were less likely to remain consistently sufficiently active, and women who reported higher levels of cancer worry were more likely to remain consistently sufficiently active. Age, stage of cancer, time since treatment, number of treatment types received, and number of physical symptoms did not predict trajectory group membership.

**Conclusions:** Women do not have uniform physical activity trajectories after treatment for breast cancer. Identification subgroups of women who do not remain consistently sufficiently active, and factors that predict these trajectories, can aid in the development of targeted behavior change interventions.

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## Introduction

An estimated 88% of women diagnosed with breast cancer are expected to live at least 5 years after being diagnosed [1]. Many will experience physical, psychological, and social challenges [2–4]. Complementary therapies should therefore be part of integrative health care programs to help women minimize the sequelae caused by cancer and the series of associated treatments. Considerable evidence supports the effectiveness of promoting physical activity (PA) as a complementary therapy after treatment for cancer. Based on recent reviews of the literature [5–10], PA can reduce clinical symptoms, improve quality of life, and decrease cancer-related morbidity and mortality risk. Moreover, a recent Cochrane Review revealed that PA at moderate-to-vigorous intensity provides greater health benefits than low-intensity PA [7]. Unfortunately, many women tend to settle into a physically inactive lifestyle after being treated for breast cancer

[11,12]. To develop and implement interventions that are effective in increasing PA, the natural patterns of PA and related personal and cancer-related characteristics associated with various patterns need to be identified. Such an understanding would allow for the detection of high-risk subgroups for targeted interventions.

Based on the teachable moment hypothesis, which suggests that cancer can serve to motivate people to adopt health-promoting behaviors [4], women may engage in PA after treatment for breast cancer. However, there is consensus that PA levels are low after treatment [11–16]. Bellizzi et al. [11] reported that more than 71% of women were not following PA recommendations, defined as accumulating at least 30 minutes of moderate activity at least 5 d/wk or 20 minutes of vigorous PA at least 3 d/wk. Similarly, Blanchard et al. [12] showed that nearly 63% of women were not following PA guidelines, defined as accumulating at least 150 minutes of moderate-to-vigorous physical activity (MVPA) or 60 minutes of vigorous PA per week. Reporting on objectively determined PA collected in the National Health and Nutrition Examination Survey 2003–2004 and 2005–2006 data, Lynch et al. [16] demonstrated that survivors spent less than 4 min/d engaged in MVPA. Although these evidence-based findings suggest that few women are active enough to obtain health benefits after treatment for breast cancer,

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studies examining PA in this population are based predominantly on cross-sectional data that can only provide a snapshot of PA behavior. Consequently, the extent to which women's PA levels change during the first few months after treatment has ended is not well understood. This reentry phase is particularly important to study because "posttreatment care is less well developed than care during the early phases of diagnosis and treatment" [17]. Characterizing women's MVPA levels during this phase can help researchers and health professionals know when interventions may have greater effects.

To date, only a few longitudinal studies have been conducted, and different patterns of PA have been reported [15,18–24]. The focus in these studies has generally been on understanding the average pattern of change in PA over time (i.e., identifying a uniform trajectory of change across all women), rather than on identifying different patterns of change that might be present within a cohort of women. Consequently, the potential heterogeneity of change in women's PA levels over time remains unexplored. The use of analytical techniques such as growth mixture modeling can help advance the understanding of the natural patterns of PA in women recently treated for breast cancer. Such techniques, which consider that multiple patterns of change might be present within a single sample, have advantages for the development and delivery of interventions during the reentry phase. Specifically, the identification of women who either remain inactive or become inactive during this phase of survivorship could be classified as a high-risk group for negative health consequences and thus would be particularly important targets for interventions.

Therefore, our main objective in this study was to identify distinct trajectories of leisure time PA in a cohort of women who reported PA levels five times over a 1-year period after primary treatment for breast cancer. MVPA was the focus in the present study because of recommendations for PA which focus on MVPA [25], and results showing that higher intensity PA has more important health outcomes than lighter intensity PA [7]. We hypothesized that at least three MVPA trajectories would be identified: one that shows stable levels, one that shows declining levels, and one that shows increasing levels. In addition, we aimed to identify personal and cancer-related characteristics that could predict MVPA patterns over time. Based on previous research [18–21,26], we examined if age, stage of cancer, time since treatment, and treatments received predicted women's trajectory group membership. Finally, given that fatigue, physical symptoms, cancer worry, and depressive symptoms are frequent problems related to breast cancer and its treatment that can interfere with women's ability to function in their roles and activities [17,27,28], we examined if these factors could also predict women's trajectory group membership.

## Materials and methods

### *Participants and procedures*

We recruited women diagnosed and treated for breast cancer through oncologist referrals and print advertisements at local medical clinics and hospitals in Montreal, QC to participate in a prospective study focused on the investigation of natural developmental changes in lifestyle behaviors. Women interested in the study contacted the research team via telephone to obtain additional details about the study and were then screened for eligibility on the basis of the following inclusion criteria: (1) an age of 18 years or older, (2) able to read, write, and understand English or French, (3) diagnosed with stage I to III breast cancer, and (4) had received and completed chemotherapy and/or radiation therapy within the previous 20 weeks. Women were excluded if they had (1) self-reported health concerns that prevented participation in PA, (2) metastatic disease, and/or (3) more than one cancer diagnosis.

Our sample included 199 women who provided data at baseline (Time 1) via questionnaires. Follow-up data collection occurred at 3 (Time 2), 6 (Time 3), 9 (Time 4), and 12 (Time 5) months thereafter via questionnaires. The retention rate was 89% ( $n = 177$ ). We credit our high rate to our extensive retention strategies, including sending (1) holiday and birthday cards, (2) newsletters with quotes from participants, data findings, and summaries of recently published relevant articles, and (3) bookmarks with our contacts and self-addressed cards to inform us of contact detail changes. Financial compensation to women for their time, as well as mailing study materials to their homes to reduce participant burden, may have also resulted in high retention. We obtained ethics approval from appropriate University and Hospital Ethics Committees before recruitment, and informed consent from women before data collection. All procedures were in accord with ethical standards outlined in the Declaration of Helsinki of 1975, as revised in 2000.

### *Measures*

#### *Physical activity*

PA was assessed at each time point using the Leisure Time Exercise Questionnaire [29]. Similar to previous research (e.g., a study by Courneya et al. [30]), we modified the Leisure Time Exercise Questionnaire instructions to assess the average duration of PA and frequency in an average week. Participants reported the amount of light, moderate, and vigorous PA during their leisure time in a typical week. As mentioned earlier, we focused on total weekly minutes of MVPA in this study given current guidelines [25], and evidence that MVPA provides greater health benefits than low-intensity PA [7]. We computed total weekly minutes of MVPA by multiplying the respective frequency and duration scores for moderate and vigorous activity, and then adding the resulting scores.

#### *Predictors*

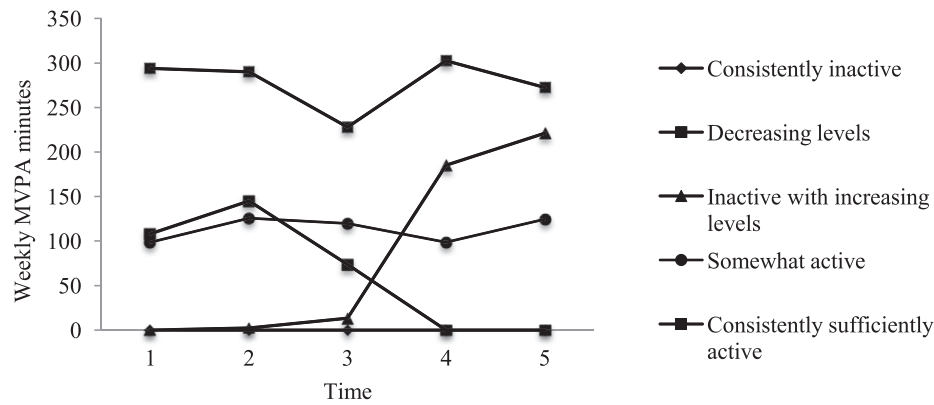
At Time 1, we collected information on participants' current age, stage of cancer at diagnosis (I, II, and III), treatment exposure (lumpectomy [no/yes], single and/or double mastectomy [no/yes], chemotherapy [no/yes], radiation [no/yes], hormonal therapy [no/yes]), and dates of diagnosis and treatment completion using a self-report questionnaire. For our analyses, we calculated the total number of treatment types women received for cancer based on the specified treatment types reported (i.e., surgery, chemotherapy, radiation, and hormonal therapy).

Depressive symptoms, fatigue, and cancer worry were assessed using the 10-item Center for Epidemiological Studies Depression [31], five-item fatigue subscale of the Profile of Mood States [32], and the six-item Assessment of Cancer Concerns scale [33], respectively. For each measure, a mean score was calculated. Physical symptoms were assessed by asking participants to report if they had experienced 12 symptoms during the day for three nonconsecutive days during the past week (no/yes). The symptoms were selected from the Patient Health Questionnaire-15 [34] and included: (1) stomach pain, (2) back pain, (3) pain in the arms, legs, or joints, (4) headaches, (5) chest pain, (6) dizziness, (7) fainting spells, (8) feeling heart pound or race, (9) shortness of breath, (10) constipation, loose bowels, or diarrhea, (11) nausea, gas, or indigestion, and (12) pain or problems during sexual intercourse. The number of physical symptoms was averaged across the 3 days.

Additional data on ethnicity, education attainment, past year household income, marital status, menopausal status, height, and weight were self-reported at Time 1 to describe the sample.

#### *Data analysis*

After descriptive analyses, main analyses proceeded in two phases. In the first phase, semiparametric group-based modeling



**Fig. 1.** Trajectories of MVPA from 199 women at baseline (Time 1, mean = 3.46 months after treatment), and 3 (Time 2), 6 (Time 3), 9 (Time 4), and 12 (Time 5) months thereafter.

was used to identify distinct trajectories of MVPA [35,36]. This technique is advantageous because it allows participants who did not provide PA data at each time point to be included in the analysis and thus makes full use of the data in determining parameter estimates [36]. A square root transformation was applied to the MVPA variable for the identification of trajectories. Initially, a single-group model saturated with quadratic parameters was tested, and then one additional group was included in successive models. When model fit stopped improving with an additional group, parameters and groups were reduced to maximize model fit. Model selection was based on the Bayesian Information Criterion (BIC), whereby the model with the lower BIC was favored [35,36]. Then, participants were assigned to the trajectory group that best corresponded to their observed behavior according to the maximum posterior probability of group membership [35]. The trajectory group memberships were used as the dependent variable in subsequent analyses to examine the predictors of the identified trajectories.

In the second phase, logistic regression was used to examine if age, stage of cancer, time since treatment, number of treatment types received, fatigue, physical symptoms, cancer worry, and depressive symptoms measured at Time 1 could predict trajectory membership. All predictors were entered into the regression equation at the same time to study the unique contribution of each predictor, while controlling for the other predictors. The odds ratios and 95% confidence intervals were examined to assess the magnitude and significance of each predictor.

## Results

### Descriptive results

The 199 women initially recruited had a mean age of 55.01 years (standard deviation (SD) = 10.96) and had a body mass index of 26.31 kg/m<sup>2</sup> (SD = 5.65) at Time 1. Most were white (84.9%), diagnosed with stage I breast cancer (41.7%) followed by stages II (39.2%) and III (19.1%), married or cohabitating with a partner (64.3%), highly educated (50.7% had a university degree), postmenopausal (64.3%), and experiencing at least one physical symptom during the past week (84.8%). Lumpectomy was the predominant surgery type (59.8%), and 64.3% were treated with chemotherapy, 88.4% with radiation therapy, and 50.8% with hormonal treatment. Overall, women had completed treatment a mean of 3.46 months (SD = 2.33) before the Time 1 assessment. Examination of mean scores for the MVPA variables revealed extreme values, defined as data points three or more SD from the mean (i.e., z-scores  $\geq |3.0|$ ) and had nonnormal distributions as measured by the univariate skewness and kurtosis values. This can reduce the power of parametric and

nonparametric tests, thus extreme values were replaced by the next highest score [37]. This procedure normalized the distribution of the MVPA scores and maintained the relative ordering of the data. The truncated scores were used for all analyses.

### Trajectories of MVPA

Using the semiparametric group-based modeling procedures, we tested single-, two-, three-, four-, five-, and six-group models. Based on the BIC criteria, the five-group model was chosen as the best-fitting model. The change in the BIC from the four-group to the five-group model showed an improvement of 30.4, whereas the change from the five-group to the six-group model showed a decrease of 8.2 in fit. Figure 1 presents the raw MVPA mean scores at each time point for each predicted trajectory group. The consistently inactive group ( $n = 11$ ; 5.5% of the sample) represented the smallest group and showed very little to no MVPA at each time point (mean<sub>Time 1–Time 5</sub> = 0 min/wk). The decreasing levels group ( $n = 19$ ; 9.5% of the sample) showed initial mean levels of 108.13 min/wk that then decreased to 0 min/wk at the final time point. The inactive with increasing levels group ( $n = 21$ ; 10.6% of the sample) showed mean levels that were similar to the consistently inactive group initially (mean<sub>Time 1</sub> = 0 min/wk), but then increased over time (mean<sub>Time 5</sub> = 221.25 min/wk). The somewhat active group ( $n = 50$ ; 25.1% of the sample) showed mean levels that varied between 98.8 and 124.41 min/wk over time and remained lower than the recommended guidelines for MVPA. Finally, the consistently sufficiently active group ( $n = 98$ ; 49.2% of the sample) showed mean levels that ranged between 227.89 and 302.49 min/wk over time—mean values that stayed above the guidelines for MVPA. The average probabilities for the assigned groups are .92, .88, .71, .82, and .86, which is above the minimum average posterior probability of .70 considered acceptable [38].

### Predictors of MVPA trajectory group membership

Table 1 presents the frequencies or means and SD for each predictor, stratified by trajectory group. Given the proportion of women in some groups was low, the trajectory groups in which women did not maintain or meet MVPA guidelines of 150 min/wk (i.e., consistently inactive, inactive with increasing levels, decreasing levels, and somewhat active trajectories; 51.8%) were combined and compared with the group of women meeting MVPA guidelines consistently over time (i.e., consistently sufficiently active). This grouping is important from a public health perspective because the women in the combined group are at higher risk of being inactive or insufficiently active to gain health benefits during

**Table 1**  
Trajectory predictors presented as frequencies or as mean and SD, stratified by trajectory group

Predictors	Consistently inactive (n = 11)	Decreasing levels (n = 19)	Inactive with increasing levels (n = 21)	Somewhat active (n = 50)	Consistently sufficiently active (n = 98)
Age in years (mean, SD)	63.73 (9.34)	56.26 (12.33)	56.52 (11.33)	53.80 (11.99)	54.07 (9.89)
Physical symptoms (mean, SD)	2.18 (1.77)	2.43 (2.08)	2.06 (1.84)	1.84 (1.40)	1.61 (1.39)
Number of treatment types received for cancer (%)					
1	9.1	5.3	—	—	2.0
2	54.5	10.5	14.3	26.0	28.6
3	27.3	63.2	61.9	44.0	39.8
4	9.1	21.1	23.8	30.0	29.6
Months since treatment (mean, SD)	3.91 (1.92)	4.79 (1.96)	3.90 (2.68)	2.94 (2.05)	3.32 (2.41)
Stage of cancer					
I	63.6	36.8	33.3	44.0	40.8
II	27.3	47.4	42.9	32.0	41.8
III	9.1	15.8	23.8	24.0	17.3
Depressive symptoms (mean, SD)	1.95 (0.56)	1.96 (0.52)	1.82 (0.47)	1.72 (0.50)	1.67 (0.51)
Cancer worry (mean, SD)	2.46 (0.81)	2.49 (0.88)	2.50 (0.64)	2.52 (0.76)	2.64 (0.78)
Fatigue (mean, SD)	1.30 (0.40)	1.65 (0.54)	1.75 (0.75)	1.43 (0.76)	1.31 (0.80)

Depressive symptoms score range = 1 to 4; cancer worry score range = 1 to 4; fatigue score range = 0 to 5.

the first year of survivorship. The overall logistic model including all predictors was significant ( $X^2 = 19.52$ ,  $df = 8$ ,  $P < .01$ ). As shown in Table 2, women who reported higher levels of depressive symptoms and fatigue at Time 1 were less likely to remain consistently sufficiently active. Those who reported higher levels of cancer worry were more likely to remain consistently sufficiently active. Age, stage of cancer, time since treatment, number of treatment types received, and number of physical symptoms at Time 1 did not predict PA patterns.

## Discussion

PA during cancer survivorship is important because it can help prevent or minimize negative physical, psychological, and social consequences resulting from cancer, as well as improve health and well-being [5–8]. This is the first study to use semiparametric group-based modeling to identify trajectories of self-reported MVPA in women as they transition through the reentry phase of survivorship. The findings support the presence of five distinct trajectories, namely consistently inactive, decreasing levels, inactive with increasing levels, somewhat active, and consistently sufficiently active. In addition, the findings suggest that depressive symptoms, cancer worry, and fatigue may help predict women's MVPA patterns in early survivorship.

### Physical activity trajectories

Breast cancer has been referred to as a teachable moment because women are likely to be motivated to adopt health-

**Table 2**  
Predictors contributing significantly to distinguishing between the MVPA trajectories

Predictors (Time 1)	Odds ratios	95% Confidence intervals
Age	0.98	0.95–1.01
Stage of cancer	0.95	0.61–1.46
Number of treatment types received	0.90	0.60–1.35
Time since treatment	0.95	0.83–1.08
Number of physical symptoms	0.89	0.72–1.11
Depressive symptoms	0.49*	0.24–0.98
Fatigue	0.67*	0.43–0.99
Cancer worry	1.53*	1.03–2.27

The reference group is the combined trajectories of consistently inactive, inactive with increasing levels, decreasing levels, and somewhat active.

\*  $P < .05$ .

promoting behaviors such as PA to improve their health and well-being [4]. In this study, approximately 11% of women reported increasing their PA levels during the reentry phase of survivorship. Andrykowski et al. [18] also reported increases in PA levels from the end of cancer treatment to 12-month posttreatment follow-up. Similarly, Huy et al. [19] reported increases in PA levels from the period during therapy to 1 year after surgery. Although the teachable moment has been commonly referred to as the period of time immediately after diagnosis [4], these findings suggest that the teachable moment may occur shortly after treatment has been completed for some women, perhaps because it is when the burdens of treatment have diminished [39]. In addition, a further 49% of women in the present study met MVPA guidelines throughout the study. These findings are encouraging and suggest not all women are inactive after treatment. Rather, they support the hypothesis that there is a considerable amount of heterogeneity in women's MVPA pattern in first few months after treatment for breast cancer has ended. Accordingly, more attention should be given to analytical techniques such as growth mixture modeling when investigating patterns of PA behavior in this population to avoid masking these unique trajectories. From a practical perspective, researchers should consider that behavior change interventions might have different effects on women in different trajectory groups.

Notwithstanding these observations, the current findings suggest that not all women are physically active during the first few months after treatment for breast cancer. Just under 20% of the women in our study were consistently inactive or had decreasing levels. These findings confirm earlier findings that PA levels can continue to decrease across the cancer trajectory [20,22]. Also, Harrison et al. [26] found that about 50% of breast cancer survivors decreased their PA levels between 6 and 18 months after diagnosis. Considering that physical inactivity places adults with a history of cancer at greater risk for morbidity, poor health outcomes, and mortality [40], women in the consistently inactive and decreasing levels trajectories represent important targets for interventions because both groups were inactive at the end of the study. This means that health care providers should ask women about their PA levels on a regular basis, and direct women who are inactive or who report decreasing levels to PA resources that are available in their communities.

### Predictors of physical activity

Previous empirical research with adults with a history of cancer has shown that personal and cancer-related characteristics are related to PA [18–21,26,41–44]. However, in our study, age, stage of cancer,

time since treatment, and number of treatment types received did not significantly predict trajectory group membership. This may suggest that the associated short- and long-term side effects of cancer and its treatment such as fatigue [28] are more important predictors. In support of this proposition, the current findings revealed that women experiencing more fatigue were less likely to maintain sufficient PA levels over time. This finding is consistent with qualitative evidence showing that fatigue is a salient barrier to maintaining PA levels among active women after treatment [45]. Specifically, Brunet et al. [45] reported that active women's experiences of treatment-related side effects were an obstacle to maintaining regular PA. Other empirical evidence also shows women experiencing side effects may have a difficult time being physically active after treatment for breast cancer [46–48]. However, given the evidence that PA can improve fatigue [6,7], strategies that seek to help women experiencing fatigue engage in PA are warranted.

Women who reported more depressive symptoms early in the survivorship period were less likely to maintain sufficient PA levels over time. Consideration of the specific symptoms common to depression may help explain these findings. For example, the somatic symptoms typically include reduced energy as a result of changes in appetite, sleep patterns, and poor sleep quality. As such, symptomatic women may undertake activities that require little or no energy expenditure rather than PA. Somatic symptoms may also impair women's functional ability [49] and thus reduce PA. The social withdrawal and isolation symptoms associated with depression [50] may have led women to choose activities that could be done alone. Because PA is often done in public place, symptomatic women may have avoided it. Thus, the degree to which depressive symptoms may have been a barrier for women should be investigated. In the meantime, it is critical to ensure that health care providers inform women experiencing depressive symptoms that PA is an important part of their psychological rehabilitation.

Many women experience considerable fear of cancer recurrence and health issues in general [17,27]. This may heighten the importance they place on lifestyle habits and prompt them to engage in PA to improve their health, prevent recurrent, and prolong survival. Indeed, it is believed that cancer can serve as a “teachable moment” because it may increase women's motivation to make positive lifestyle changes to reduce the lasting health threats of the disease [4]. In line with this hypothesis, we found that women who reported more concerns for cancer and general health were more likely to maintain sufficient PA levels into survivorship. In light of these findings and evidence for the benefits of PA [5–8], an important endeavor is therefore to frame PA messages to promote PA as a strategy to promote general health and reduce the risk of recurrence.

#### Study limitations

This study has some limitations. First, the sample was a convenience sample of volunteer women who were predominantly white and well educated which may not be representative, and may limit generalizability of the findings. Future research should examine if the identified trajectories are replicable in other groups (e.g., nonwhite, women without a university degree). Second, PA was assessed via self-report, which may have introduced some measurement error. Relatedly, women reported high levels in general. It is possible that PA scores were higher than had objective methods been used [16]. This calls for more research using objective methods to confirm these trajectories. Third, although our approach to combine trajectories groups was helpful to increase our power to identify predictors, future studies with larger samples are needed to examine the association of each predictor with each individual trajectory group. Last, PA before and during treatment was not assessed, and therefore could not be examined as a predictor of

posttreatment MVPA patterns. Also, different trajectories may have emerged if data were collected over a longer period of time (e.g., diagnosis or active treatment periods).

#### Conclusion

In this study, we identified five distinct trajectories of PA in a cohort of women treated for breast cancer. This adds to the limited research covering the reentry phase of cancer survivorship (i.e., the first 12 to 18 months after cancer treatment) when health behavior interventions might be appropriate [39], and cancer care programs are limited [17]. These findings have implications for future research. Specifically, they suggest researchers should consider using analytical techniques that can capture the heterogeneities in women's PA patterns after treatment. Of particular importance is to investigate if the identified trajectories herein persist over the extended survivorship phase and examine which patterns of change are associated with fewer adverse health outcomes over time. It would also be of interest to examine additional factors that may enable better prediction of trajectory group membership.

The identification of different trajectories of PA also has implications for the targeting of behavior change interventions. Specifically, the finding that nearly 20% of women were consistently inactive or had decreasing levels, coupled with evidence that physical inactivity is hazardous to health [40], make these women important targets for interventions. Based on the analysis of factors that predicted trajectory group membership in this study, interventions should prioritize women who experience depressive symptoms and fatigue shortly after treatment.

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