




# Physical activity levels among ovarian cancer survivors: a prospective longitudinal cohort study

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## HIGHLIGHTS

- Within 2-years post-diagnosis of ovarian cancer, average physical activity levels are below recommended levels.
- More than 50% of women with ovarian cancer report a decrease or no change in physical activity levels post-diagnosis.
- Future research now needs to evaluate the safety, feasibility, and effect of exercise post-ovarian cancer.

## ABSTRACT

**Objective** Physical activity following cancer diagnosis is associated with improved outcomes, including potential survival benefits, yet physical activity levels among common cancer types tend to decrease following diagnosis and remain low. Physical activity levels following diagnosis of less common cancers, such as ovarian cancer, are less known. The objectives of this study were to describe physical activity levels and to explore characteristics associated with physical activity levels in women with ovarian cancer from pre-diagnosis to 2 years post-diagnosis.

**Methods** As part of a prospective longitudinal study, physical activity levels of women with ovarian cancer were assessed at multiple time points between pre-diagnosis and 2 years post-diagnosis. Physical activity levels and change in physical activity were described using metabolic equivalent task hours and minutes per week, and categorically (sedentary, insufficiently, or sufficiently active). Generalized Estimating Equations were used to explore whether participant characteristics were related to physical activity levels.

**Results** A total of 110 women with ovarian cancer with a median age of 62 years (range 33–88) at diagnosis were included. 53–57% of the women were sufficiently active post-diagnosis, although average physical activity levels for the cohort were below recommended levels throughout the 2-year follow-up period (120–142.5min/week). A decrease or no change in post-diagnosis physical activity was reported by 44–60% of women compared with pre-diagnosis physical activity levels. Women diagnosed with stage IV disease, those earning a lower income, those receiving chemotherapy, and those currently smoking or working were more likely to report lower physical activity levels and had increased odds of being insufficiently active or sedentary.

**Conclusions** Interventions providing patients with appropriate physical activity advice and support for behavior change could potentially improve physical activity levels and health outcomes.

## INTRODUCTION

In recent years the efficacy of physical activity and exercise across the cancer continuum has been extensively investigated.<sup>1 2</sup> While physical activity encompasses all bodily movement (including exercise), exercise is planned and structured with the intent of improving specific outcomes.<sup>3</sup> Benefits associated with physical activity and exercise during treatment and following diagnosis have resulted in statements and guidelines from national and international organizations.<sup>1 2</sup> Internationally endorsed physical activity guidelines recommend that cancer survivors should participate in 150 min/week physical activity and strength training,<sup>4–6</sup> with calls for physical activity and exercise to be incorporated into standard cancer care.<sup>7</sup>

Physical activity has been associated with survival outcomes, including all-cause and cancer-specific mortality, with findings from a recent systematic review and meta-analysis showing improved survival outcomes in 10 cancer types for those in the highest category of post-diagnosis physical activity compared with those in the lowest physical activity category.<sup>8</sup> In particular, preliminary evidence supports the relationship between post-diagnosis physical activity and overall survival following a diagnosis of ovarian cancer.<sup>9</sup> Additionally, declines in physical activity following a cancer diagnosis have been associated with poorer overall survival.<sup>10</sup> Furthermore, the American College of Sports Medicine recently released guidelines stating that there was strong evidence in support of the benefits of exercise in the management of cancer-related health outcomes including anxiety, depression, fatigue, health-related quality of life, lymphedema, and physical function.<sup>1</sup>

Despite the evidence that participating in regular physical activity is beneficial for people with cancer, epidemiological findings suggest that physical activity levels tend to decrease following diagnosis



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## Original research

and remain low, with the majority of cancer survivors not meeting recommended physical activity levels 12 months or more following diagnosis.<sup>11–13</sup> However, the understanding of post-diagnosis physical activity patterns is largely derived from mixed cancer patient samples or patients with common cancer types such as breast and colorectal cancer.<sup>11 12</sup> In contrast, physical activity levels and changes in physical activity following diagnosis for those with less common cancers, in particular cancers that confer a poorer prognosis, are less well studied. A recent review of studies evaluating physical activity levels in ovarian cancer found that most women decrease their physical activity post-diagnosis and remain insufficiently active beyond the treatment period, with the majority failing to meet physical activity recommendations.<sup>13 14</sup> However, it was also noted that these findings were largely drawn from cross-sectional or retrospective studies, with few assessing physical activity prospectively and a lack of data on physical activity during the first year following diagnosis.<sup>13 14</sup>

As part of a prospective longitudinal cohort study, self-reported physical activity levels from pre-diagnosis through to 2 years post-diagnosis were collected from women with ovarian cancer.<sup>15</sup> The objectives of this study were (1) to describe physical activity levels within the first 2 years following ovarian cancer diagnosis; (2) to describe changes in physical activity levels between pre-diagnosis and 2 years post-ovarian cancer diagnosis; and (3) to explore the characteristics associated with physical activity levels from pre-diagnosis to 2 years post-diagnosis in women with ovarian cancer.

## METHODS

### Study design and subjects

Physical activity levels from pre-diagnosis to 2 years post-diagnosis were assessed as part of a prospective longitudinal cohort study in women with ovarian cancer.<sup>15 16</sup> Women were eligible to participate if they were aged  $\geq 18$  years, newly diagnosed with ovarian cancer, and treated at participating hospitals in Queensland, New South Wales and Victoria, Australia.<sup>15 16</sup>

### Timing of data collection

Following informed consent, baseline data were collected approximately 1 week prior to diagnostic surgery and definitive gynecological cancer diagnosis. Subsequent assessments were coordinated with the participant's scheduled hospital follow-up visits between 6 weeks and 2 years post-diagnosis. Follow-up schedules differed between participants, therefore depending on the timing of the participant's follow-up appointments, assessments were conducted a maximum of 10 times over the study period (ie, at 6 weeks and 3, 6, 9, 12, 15, 18, 21, and 24 months post-diagnosis).

### Data collection

Physical activity levels were assessed using the self-report Active Australia Survey, for which good to excellent reliability and acceptable validity have been reported.<sup>17</sup> Women were asked to report the frequency and duration of activity completed in the previous week (number of sessions and time spent in each activity), including walking, moderate- and vigorous-intensity physical activity, from which min/week of each physical activity type was calculated. 'Total Activity' per week was calculated based on the sum of moderate- (including walking) and vigorous-intensity activity (weighted by

two).<sup>17</sup> Total metabolic equivalent task (MET) hours/week were then calculated using min/week of moderate- and vigorous-intensity physical activity, with MET values of 4.0 and 8.0 assigned to moderate- and vigorous-intensity activity, respectively.<sup>18</sup> Weekly MET hours were calculated by multiplying the duration of activity per week by the assigned MET value, with Total MET hours/week calculated based on the sum of moderate- and vigorous-intensity activity. Using Total MET hours/week, women were classified into physical activity categories: 'Sedentary' (0 MET hours/week); 'Insufficiently Active' ( $< 7.5$  MET hours/week), or 'Sufficiently Active' ( $\geq 7.5$  MET hours/week), according to the minimum energy expenditure of global physical activity recommendations (150 min/week of moderate-intensity physical activity).<sup>4 19</sup>

Participant characteristics including demographic information, socioeconomic and marital status, and lifestyle behaviors were collected via a participant-administered questionnaire at baseline. Clinical information concerning diagnosis and treatment were abstracted by trained research nurses from medical records at baseline and at the 2-year follow-up.

### Statistical methods

Due to differences in the number and timing of follow-up visits for each participant, follow-up visits were grouped into time phases for analysis of physical activity data: baseline (T1; pre-definitive diagnosis), 6 weeks to 3 months (T2), 6 months to 1 year (T3), and 15 months to 2 years post-diagnosis (T4). For T2–T4, physical activity measures were averaged if multiple surveys were completed within each time phase.

Physical activity levels were described at each time phase using min/week and MET hours/week, with both mean and medians presented due to the skewed nature of the data. Change in physical activity levels were described using continuous change (Total Activity and Total MET hours/week at T2–T4 minus baseline levels), as well as categorial change. Based on values previously reported in the literature, a clinically significant change in physical activity was determined *a priori* as a difference of 30 min in Total Activity per week or 3 METs in Total MET hours/week.<sup>20 21</sup> Participants were then categorized as having 'Increased', 'Decreased' or reported 'No Change' in physical activity from baseline to T2–T4.

Using all available data from T1–T4, linear and binary logistic Generalized Estimating Equations were used to explore the relationship between physical activity levels (continuous; Total MET hours/week and categorial; 'Sufficiently Active' vs 'Insufficiently Active', respectively) and individual baseline personal, diagnostic, treatment, and behavioral characteristics. Characteristics of theoretical importance (based on previous literature), as well as statistical ( $p < 0.05$ ) or clinical significance (3 MET hours/week difference between groups or OR of  $\leq 0.6$  or  $\geq 1.5$ ) were then included in separate models, adjusting for age and body mass index at diagnosis.<sup>15 20 21</sup> When physical activity levels were assessed as a continuous variable, the effect size of the relationship was described using beta values and standard errors for continuous independent variables and estimated marginal means and standard errors for categorical independent variables. When physical activity was assessed as a categorical variable, relationships with independent variables were described using ORs and 95% confidence intervals.

**Table 1** Participant characteristics of women in the Lymphedema Evaluation in Gynecological cancer Study (LEGS) diagnosed with ovarian cancer

Characteristics (n=110)			
Age, years		Menstrual status, n (%)	
Mean±SD	60.72±10.68	Pre-/peri-menopausal	18 (16.4)
Range	33–88	Post-menopausal	92 (83.6)
Weight, kg		Surgery, n (%)	
Median (range)	68.75 (45.0–136.8)	Laparotomy	96 (87.3)
Body mass index (BMI), kg/m <sup>2</sup>		Lymph node dissection, n (%)	
Median (range)	25.8 (17.5–52.1)	Yes	42 (38.2)
BMI categories, n (%)		Chemotherapy, n (%)	
Underweight/normal	43 (39.1)	Adjuvant±neoadjuvant	88 (80.0)
Overweight	36 (32.7)	No chemotherapy	17 (15.5)
Obese	29 (26.4)	Unknown	5 (4.5)
Unknown	2 (1.8)	Highest education, n (%)	
Stage, n (%)		Grade 12 or below	66 (60.0)
Stage I	26 (23.6)	Trade/University	28 (25.5)
Stage II	14 (12.7)	Other	10 (9.1)
Stage III	53 (48.2)	Unknown	6 (5.5)
Stage IV	14 (12.7)	Employment status, n (%)	
Unknown	3 (2.7)	Full-time/part-time/casual	25 (22.7)
Histological type, n (%)		Retired/home duties	66 (60.0)
Epithelial	101 (91.8)	Other	13 (11.8)
Other	5 (4.5)	Unknown	6 (5.5)
Unknown	4 (3.6)	Marital status, n (%)	
ECOG status, n (%)		Married/de facto	66 (60.0)
0	92 (83.6)	Not married	37 (33.6)
1	16 (14.5)	Other	1 (0.9)
2	2 (1.8)	Unknown	6 (5.5)
Smoking, n (%)		Household income, n (%)	
Never/past	95 (86.4)	≤\$60 000	71 (64.5)
Current	11 (10.0)	>\$60 000	19 (17.3)
Unknown	4 (3.6)	Unknown	20 (18.2)
Birth country, n (%)			
Australia	79 (71.8)		
Other	30 (27.3)		
Unknown	1 (0.9)		

## RESULTS

As part of the wider study, a total of 110 women with ovarian cancer completed baseline assessment, at least one follow-up assessment, and provided data on at least one outcome such as physical activity or lymphedema.<sup>15 16</sup> The number of participants who contributed physical activity data and were included in this analysis ranged from 84 to 98 (T1: n=94; T2: n=98; T3: n=94; T4: n=84). Participant demographics are shown in Table 1. Overall, the sample had an average age of 61±11 years and a median body mass index of 26 kg/m<sup>2</sup> (range 18–52 kg/m<sup>2</sup>). The majority were diagnosed with late stage disease (n=67, 61%), epithelial cancer (n=101, 92%), and had received chemotherapy (n=88, 80%), with

a laparotomy being the most common surgical approach (n=96, 87%).

### Physical activity levels

Weekly physical activity levels from T1 to T4 are shown in Table 2. Weekly minutes for walking and moderate-intensity activities were lowest at baseline before increasing from T1 to T3 and then plateauing between T3 and T4. This trend was reflected in 'Total Activity' (min/week) and 'Total MET hours/week'. 'Vigorous gardening or housework' showed an upward trend across the 2-year follow-up period and mean 'Vigorous physical activity' returned to baseline levels by T3 and T4, following a decrease at

**Table 2** Weekly physical activity reported by women with ovarian cancer at each time point

	T1 (n=94)	T2 (n=98)	T3 (n=94)	T4 (n=84)
Walking for recreation (min/week)				
Median (min, max)	30.00 (0.00, 480.00)	52.50 (0.00, 820.00)	60.00 (0.00, 595.00)	53.75 (0.00, 840.00)
Mean (SE)	75.92 (11.56)	86.32 (11.94)	97.65 (11.53)	96.67 (15.39)
Walking for exercise (min/week)				
Median (min, max)	30.00 (0.00, 420.00)	45.00 (0.00, 840.00)	56.67 (0.00, 400.00)	35.00 (0.00, 345.00)
Mean (SE)	59.74 (9.33)	77.67 (11.59)	88.88 (9.78)	67.76 (9.23)
All walking (min/week)				
Median (min, max)	77.50 (0.00, 770.00)	120.00 (0.00, 1090.00)	126.25 (0.00, 653.33)	101.67 (0.00, 870.00)
Mean (SE)	128.60 (17.06)	163.08 (19.42)	181.32 (18.19)	164.44 (21.08)
Other moderate physical activity (min/week)				
Median (min, max)	0.00 (0.00, 400.00)	0.00 (0.00, 322.50)	0.00 (0.00, 300.00)	0.00 (0.00, 380.00)
Mean (SE)	13.44 (7.07)	13.06 (4.72)	31.36 (7.08)	35.47 (7.90)
All moderate activity (min/week)				
Median (min, max)	85.00 (0.00, 830.00)	120.00 (0.00, 1412.50)	135.83 (0.00, 855.00)	127.50 (0.00, 940.00)
Mean (SE)	140.10 (19.02)	174.04 (21.49)	211.32 (21.55)	197.47 (24.26)
Vigorous gardening or housework (min/week)				
Median (min, max)	0.00 (0.00, 300.00)	0.00 (0.00, 840.00)	14.33 (0.00, 420.00)	20.00 (0.00, 820.00)
Mean (SE)	21.90 (5.68)	51.20 (12.57)	58.13 (9.39)	64.87 (14.77)
Vigorous physical activity (min/week)				
Median (min, max)	0.00 (0.00, 540.00)	0.00 (0.00, 200.00)	0.00 (0.00, 435.00)	0.00 (0.00, 315.00)
Mean (SE)	20.12 (9.17)	8.91 (2.98)	21.02 (6.12)	21.85 (6.10)
Total activity (min/week)				
Median (min, max)	90.00 (0.00, 1345.00)	120.00 (0.00, 1517.00)	140.00 (0.00, 1033.33)	142.50 (0.00, 1470.00)
Mean (SE)	175.26 (29.18)	189.88 (24.62)	251.53 (26.52)	238.26 (32.73)
Total MET hours/week				
Median (min, max)	6.00 (0.00, 89.67)	8.00 (0.00, 101.17)	9.33 (0.00, 68.89)	9.50 (0.00, 98.00)
Mean (SE)	11.68 (1.95)	12.66 (1.64)	16.77 (1.77)	15.88 (2.18)

T1: baseline; T2: 6 weeks to 3 months post-diagnosis; T3: 6 months to 1 year post-diagnosis; T4: 15 months to 2 years post-diagnosis.  
MET, metabolic equivalent task.

T2. At 2 years post-diagnosis (T4), average physical activity levels were 142.50 min/week ('Total Activity') and 9.50 MET hours/week.

Table 3 shows the proportion of women meeting physical activity guidelines based on Total MET hours/week. Between T1 and T4, 9–19% of women were 'Sedentary' and 29–37% were 'Insufficiently Active'. Pre-diagnosis (T1; baseline), 40% of women were categorized as being 'Sufficiently Active', whereas by T4, 56% reported physical activity levels consistent with meeting physical

activity guidelines. Data presented in Table 4 suggest that the average change between T1 and T2–T4 was positive—that is, on average women increased physical activity levels between time of diagnosis and 2 years post-diagnosis. When women were categorized according to change in physical activity levels based on Total MET hours/week, 60%, 44%, and 53% reported either 'No Change' or 'Decreased' physical activity levels between T1 and T2–T4, respectively. Figure 1 shows the proportion of women who

**Table 3** Proportion of women meeting physical activity guidelines and corresponding total MET hours/week at each time point

	T1 (n=91)		T2 (n=97)		T3 (n=92)		T4 (n=83)	
	N (%)	Median (min, max)	N (%)	Median (min, max)	N (%)	Median (min, max)	N (%)	Median (min, max)
<b>Sedentary</b> (0 MET hours/week)	18 (19.1)	0.00 (0.00, 0.00)	10 (10.2)	0.00 (0.00, 0.00)	8 (8.5)	0.00 (0.00, 0.00)	12 (14.3)	0.00 (0.00, 0.00)
<b>Insufficiently Active</b> (<7.5 MET hours/week)	35 (37.2)	3.33 (0.27, 7.33)	35 (35.7)	4.00 (0.33, 7.33)	30 (31.9)	4.33 (0.67, 7.33)	24 (28.6)	3.42 (0.50, 6.78)
<b>Sufficiently Active</b> (≥7.5 MET hours/week)	38 (40.4)	14.00 (8.00, 89.67)	52 (53.1)	15.00 (7.57, 101.17)	54 (57.4)	24.00 (7.67, 68.89)	47 (56.0)	18.00 (8.00, 98.00)

T1: baseline; T2: 6 weeks to 3 months post-diagnosis; T3: 6 months to 1 year post-diagnosis; T4: 15 months to 2 years post-diagnosis.  
MET, metabolic equivalent task.

**Table 4** Change in physical activity levels

	Change between T1 and T2			Change between T1 and T3			Change between T1 and T4		
	N	Mean (SE)	Median (min, max)	N	Mean (SE)	Median (min, max)	N	Mean (SE)	Median (min, max)
Total Activity (min/week)	82	22.29 (33.84)	17.50 (-1180.00, 1290.00)	75	73.11 (88.01)	85.00 (-1190.00, 995.00)	66	47.59 (44.24)	28.75 (-1270.00, 1060.00)
Total MET hours/week	82	1.49 (2.26)	1.17 (-78.67, 86.00)	75	4.87 (2.53)	5.67 (-79.33, 66.33)	66	3.17 (2.95)	1.92 (-84.67, 70.67)
Total Activity (min/week)*									
	n (%)	Mean (SE)	Median (min, max)	n (%)	Mean (SE)	Median (min, max)	n (%)	Mean (SE)	Median (min, max)
Increased	3 (42.7)	228.39 (40.72)	172.50 (37.50, 1290.00)	42 (56.0)	256.94 (92.04)	166.67 (60.00, 995.00)	32 (48.5)	286.37 (44.14)	195.00 (41.67, 1060.00)
Decreased	25 (30.5)	-252.36 (61.22)	-140.00 (-1180.00, -40.00)	17 (22.7)	-307.26 (91.40)	-169.33 (-1190.00, -30.00)	19 (28.8)	-317.11 (77.85)	-140.00 (-1270.00, -40.00)
No change	22 (26.8)	6.52 (3.37)	1.25 (-30.00, 30.00)	16 (21.3)	-5.30 (3.75)	-4.50 (-26.67, 25.00)	15 (22.7)	0.17 (5.04)	0.00 (-27.50, 30.00)
Total MET hours/week†									
	n (%)	Mean (SE)	Median (min, max)	n (%)	Mean (SE)	Median (min, max)	n (%)	Mean (SE)	Median (min, max)
Increased	33 (40.2)	15.99 (2.83)	12.00 (3.33, 86.00)	42 (56.0)	17.13 (2.14)	11.11 (4.00, 66.33)	31 (46.9)	19.62 (2.99)	13.50 (4.25, 70.67)
Decreased	23 (28.0)	-18.05 (4.35)	-9.33 (-78.67, -3.33)	13 (17.3)	-26.04 (7.33)	-14.67 (-79.33, -3.33)	17 (25.8)	-23.30 (5.58)	-9.83 (-84.67, -4.08)
No change	26 (31.7)	0.36 (0.28)	0.08 (-2.83, 2.67)	20 (26.7)	-0.77 (0.28)	-0.67 (-2.67, 1.67)	18 (27.3)	-0.15 (0.39)	0.00 (-3.00, 2.78)

T1: baseline; T2: 6 weeks to 3 months post-diagnosis; T3: 6 months to 1 year post-diagnosis; T4: 15 months to 2 years post-diagnosis.

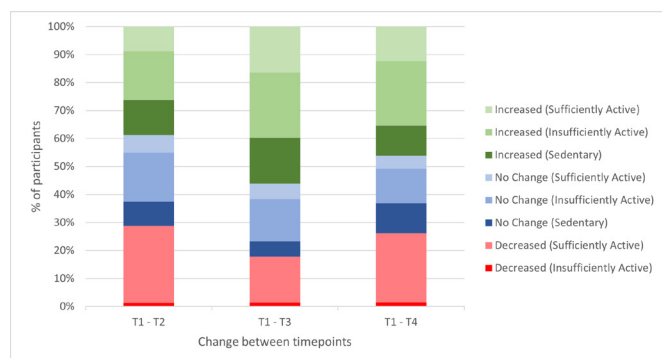
\*30 min/week indicated a clinically significant change in Total Activity (min/week).

†3 MET hours/week indicated a clinically significant change in Total MET hours/week.

MET, metabolic equivalent task.



## Original research



**Figure 1** Clinically significant change in physical activity levels according to baseline physical activity category, where 3 MET hours/week indicates a clinically significant change. Sedentary: 0 MET hours/week; Insufficiently Active: <7.5 MET hours/week; Sufficiently Active:  $\geq 7.5$  MET hours/week. T1: baseline; T2: 6 weeks to 3 months post-diagnosis; T3: 6 months to 1 year post-diagnosis; T4: 15 months to 2 years post-diagnosis. MET, metabolic equivalent task.

experienced clinically relevant changes in physical activity levels between T1 and T2–T4, according to T1 physical activity categories (ie, Sedentary, Insufficiently Active, or Sufficiently Active). Among women who were ‘Sufficiently Active’ at T1, approximately 60% had experienced clinically relevant declines in physical activity by T4. Additionally, among those who experienced a clinically relevant decrease in physical activity between T1 and T2–T4, over 90% were women who were ‘Sufficiently Active’ at T1.

Table 5 reports participant characteristics associated with physical activity levels. Following adjustment for age and BMI (with higher BMI associated with lower levels of physical activity,  $p=0.05$ ), diagnosis with stage IV disease ( $p>0.05$ ), lower income ( $p>0.05$ ), receipt of chemotherapy (adjuvant±neoadjuvant;  $p<0.05$ ), smoking ( $p<0.05$ ), and currently working ( $p<0.05$ ) were associated with lower levels of physical activity. These same characteristics were associated with increased odds of being insufficiently active or sedentary. Lymph node dissection ( $p>0.05$ ) was associated with higher physical activity levels and reduced odds of being insufficiently active or sedentary.

## DISCUSSION

### Summary of main results

The results from this prospective longitudinal cohort study suggest that, while approximately one in two women met physical activity guidelines post-ovarian cancer diagnosis, average physical activity levels for the cohort were below recommended levels.<sup>4–6</sup> Additionally, by 2 years post-diagnosis, over half of the women reported either ‘No Change’ or a ‘Decrease’ in physical activity, with over 90% of those who reported a ‘Decrease’ having been ‘Sufficiently Active’ at baseline. Compared with those reporting higher levels of physical activity and meeting physical activity guidelines, women diagnosed with stage IV disease, those who were currently working, those earning a lower income, those receiving chemotherapy, and those who were currently smoking were more likely to report lower levels of physical activity and not meet physical activity guidelines.

### Results in the context of published literature

In the current study, 53–57% of women reported being ‘Sufficiently Active’ (ie, meeting physical activity guidelines) post-diagnosis. This proportion is higher than previously observed, with several studies reporting that only 9–21% of women with ovarian cancer met physical activity guidelines between approximately 2–3 years post-diagnosis.<sup>9 22 23</sup> It is also higher than those previously observed in mixed (21–41%; up to 21 years post-diagnosis),<sup>24 25</sup> breast (21–40%; 2–10 years post-diagnosis),<sup>26</sup> and gynecological cancer cohorts (9–53%; 6–24 months post-diagnosis).<sup>13</sup> Differences in timing of assessment and study design may be contributing to these differences. Specifically, the study was longitudinal with prospective repeated measures of physical activity, whereas the broader evidence regarding physical activity post-cancer (particularly post-ovarian cancer) is derived from cross-sectional studies and/or retrospective data collection processes.<sup>14</sup> Further, few studies involving gynecological cancer cohorts have assessed physical activity in the first year post-diagnosis.<sup>14</sup>

The findings reported here suggest that physical activity levels increased from baseline through to 2 years post-diagnosis assessment. However, our baseline physical activity assessment coincided with the point of diagnosis, a time typically associated with unresolved or heightened disease-related symptoms, pre-operative appointments and psychological stress, all of which would likely contribute to lower levels of baseline physical activity than would be observed in the year or decade prior to diagnosis. Consequently, it would be anticipated that resolution or stability of symptoms through treatment could contribute to the mean increase in physical activity levels observed. Also of note, however, less than half of the participants contributed to the mean increase observed over time; specifically, 27% and 26% of women reported either ‘No Change’ or a ‘Decrease’ in physical activity between baseline (at diagnosis) and 2 years post-diagnosis, respectively. Additionally, of those reporting a ‘Decrease’ in physical activity, over 90% had been ‘Sufficiently Active’ at baseline. Furthermore, overall average physical activity levels remained below the recommended 150 min/week throughout the entire 2-year follow-up.<sup>4–6</sup> These findings are consistent with physical activity levels observed in other more commonly studied cancer cohorts,<sup>11 12 26</sup> and support the inclusion of women meeting physical activity guidelines in exercise intervention or physical activity programs, with the goal of maintaining physical activity post-diagnosis. Considering the benefits of physical activity and exercise on cancer-specific health outcomes,<sup>1 2</sup> it is important to understand how the challenges experienced by women with ovarian cancer may impact physical activity levels and whether the current guidelines are appropriate for this specific cancer type. Combining this understanding with the literature examining physical activity preferences (eg, home-based, walking), barriers and identifying those at risk of physical inactivity would further improve our ability to provide appropriate physical activity advice.<sup>27 28</sup>

The findings from this study also suggest that several characteristics are associated with reporting lower levels of physical activity and increased odds of being insufficiently active or sedentary. These include being diagnosed with stage IV disease, receipt of chemotherapy, lower income, smoking, or currently working. Given the morbidity associated with treatment for more advanced disease (including more extensive surgery), it is possible that side effects

**Table 5** Characteristics associated with physical activity levels

Characteristics	Continuous physical activity* (Total MET hours/week)					Categorical physical activity* (odds of being insufficiently active)				
	$\beta$	SE	95% Wald CI		P value	Exp ( $\beta$ )	95% Wald CI for Exp ( $\beta$ )		P value	
			Lower	Upper			Lower	Upper		
Age (years)	-0.08	0.10	-0.29	0.12	0.42	1.02	0.99	1.04	0.30	
Body mass index (kg/m <sup>2</sup> )	-0.35	0.17	-0.69	-0.01	0.05	1.01	0.96	1.06	0.73	
	%	EM Mean	SE (EM Mean)	95% Wald CI		P value	Exp ( $\beta$ )	95% Wald CI for Exp ( $\beta$ )		P value
				Lower	Upper			Lower	Upper	
<i>Stage Intercept</i>	n=105					<b>0.00</b>				<b>0.37</b>
Stage						0.44				0.48
Stage I	27.70%	14.80	2.38	10.15	19.46	Ref	Ref	Ref	Ref	Ref
Stage II	12.40%	12.21	3.02	6.29	18.12	0.49	1.25	0.45	3.46	0.67
Stage III	47.30%	15.98	2.12	11.83	20.12	0.71	0.99	0.50	1.95	0.97
Stage IV	12.70%	11.21	2.34	6.62	15.79	0.28	1.91	0.74	4.93	0.18
<i>Income Intercept</i>	n=89					<b>0.01</b>				<b>0.50</b>
Income						0.39				0.36
>\$60 000+	21.70%	12.02	3.01	6.13	17.91	0.39	1.51	0.62	3.66	0.36
≤\$60 000	78.30%	15.12	1.68	11.83	18.41	Ref	Ref	Ref	Ref	Ref
<i>Lymph node dissection Intercept</i>	n=108					<b>0.01</b>				<b>0.57</b>
Lymph node dissection						0.05				0.05
Yes	39.70%	17.46	1.92	13.69	21.24	0.05	0.56	0.31	0.99	0.05
No	60.30%	12.25	1.68	8.95	15.54	Ref	Ref	Ref	Ref	Ref
<i>Chemotherapy Intercept</i>	n=103					<b>0.00</b>				<b>0.19</b>
Chemotherapy						0.43				0.32
Adjuvant ±neoadjuvant	81.90%	14.18	1.45	11.33	17.03	0.43	1.48	0.69	3.20	0.32
No chemotherapy	18.10%	16.78	2.94	11.02	22.54	Ref	Ref	Ref	Ref	Ref
<i>Smoking Intercept</i>	n=104					<b>0.00</b>				<b>0.46</b>
Smoking						0.01				0.06
Current	10.40%	9.26	1.70	5.92	12.60	0.01	2.07	0.98	4.33	0.06
Never/past	89.60%	15.07	1.43	12.27	17.87	Ref	Ref	Ref	Ref	Ref
<i>Employment Intercept</i>	n=102					<b>0.00</b>				<b>0.21</b>
Employment						0.22				0.36
Other	13.10%	12.92	2.51	8.00	17.84	0.48	0.90	0.38	2.13	0.81
Retired/home duties	62.80%	16.42	1.87	12.75	20.09	0.09	0.60	0.29	1.27	0.18
Full-time/part-time/casual	24.10%	10.41	2.69	5.15	15.68	Ref	Ref	Ref	Ref	Ref

\*All available data at all time points contributed to the analysis.  
EM mean, estimated marginal mean; MET, metabolic equivalent task.

associated with diagnosis of stage IV disease and receipt of chemotherapy would present barriers to participating in higher levels of physical activity and meeting recommended physical activity levels.<sup>4-6 29 30</sup> Lower socioeconomic status, time constraints, and participating in poor lifestyle behaviors have previously been associated with lower levels of physical activity in other cancer cohorts and chronic diseases.<sup>31-33</sup> In the current analysis, lower income and currently working or smoking may represent potential surrogate measures for these characteristics. More difficult to understand was our observation that having lymph node dissection was associated with higher levels of physical activity and being less likely to be insufficiently active or sedentary. Women who received more extensive lymph node dissection (and consequently had a higher incidence of lower limb lymphedema) may have been referred to a

lymphedema specialist, potentially being encouraged to participate in more activity as part of lymphedema treatment.<sup>15 34</sup> It is relevant to highlight that, while these results provide preliminary evidence supporting specific associations between patient, treatment and behavioral characteristics and physical activity levels, they represent partially-adjusted findings. A larger sample size would provide greater statistical power for a more in-depth analysis, with subsequent findings able to identify those most in need of physical activity support post-diagnosis.

### Implications for practice and future research

The current evidence in support of physical activity (including exercise) post-cancer is largely based on studies that have involved more common cancer types with high survival rates,<sup>1 2 35</sup> with only

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preliminary (although supportive) evidence available in the ovarian cancer population.<sup>14</sup> However, women with ovarian cancer typically have a poorer prognosis, more advanced disease at diagnosis, and require more extensive surgery and adjuvant treatment than the more common cancer types.<sup>36 37</sup> This study provides the first longitudinal evidence with prospective assessment of physical activity levels during a previously understudied time period (first year post-diagnosis of ovarian cancer). The subsequent findings suggest that within the first 2 years post-diagnosis of ovarian cancer, on average, women engage in physical activity levels below those recommended to cancer populations. Furthermore, >50% either report no change in their physical activity or declines in their physical activity between diagnosis and 2 years post-diagnosis. Future research is now required to determine whether recommended levels are safe, feasible, and beneficial for this specific subgroup of the cancer population. A more in-depth understanding would also allow for the development of targeted physical activity and exercise recommendations that can accommodate the specific needs of the ovarian cancer population.

### Strengths and weaknesses of the study

Strengths of this work include the prospective longitudinal design and 2-year follow-up, which clearly includes the previously understudied time frame of <12 months post-diagnosis and minimizes bias associated with retrospective and distant recall.<sup>38 39</sup> Additionally, the sample is representative of the wide cancer population, specifically with regard to age at diagnosis, stage and histological type of disease, and treatment patterns.<sup>36 40</sup> In contrast, study limitations include self-reported physical activity assessment (although using a validated instrument), which is subject to misinterpretation of exercise intensity and overestimation of physical activity levels,<sup>17 41 42</sup> and relatively small sample size preventing fully-adjusted regression analyses.

### CONCLUSIONS

The findings from this work suggest that there is scope for women with ovarian cancer to benefit from participation in regular physical activity along with planned structured exercise.<sup>14</sup> Additionally, the results from the current study demonstrate that average physical activity is below recommended guidelines, suggesting that there is capacity to positively influence physical activity levels in this cohort and potentially improve health, quality of life, and survival outcomes.

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