



# Factors associated with changes in exercise behaviors during the COVID-19 pandemic

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## Abstract

**Purpose** There is limited information on how the COVID-19 pandemic has changed health behaviors among cancer patients. We examined changes in exercise behaviors since the pandemic and identified characteristics associated with these changes among cancer patients.

**Methods** Cancer patients ( $n = 1,210$ ) completed a survey from August to September 2020 to assess COVID-19 pandemic-related changes in health behaviors and psychosocial factors. Patients were categorized into three groups: exercising less, exercising did not change, and exercising more. Patient characteristics were compared by exercise groups.

**Results** One-third of the patients reported a decreased amount of regular exercise, while 10% reported exercising more during the pandemic. Patients who exercised less were more likely to be unemployed/retired and have poor health status and psychosocial stressors such as disruptions in daily life while less likely to be former smokers (all  $p < 0.05$ ). In contrast, patients who exercised more were younger, had stage IV diagnosis, and also reported disruptions in daily life (all  $p < 0.05$ ). Patients who were living in rural areas were also more likely not to experience changes in exercise habits (all  $p < 0.05$ ), although rural–urban status was not identified as a strong predictor.

**Conclusion** A significant proportion of cancer patients experienced changes in exercise habits, especially exercising less, during the first 6 months of the COVID-19 pandemic. Age, employment status, tumor stage, health status, smoking status, and psychosocial factors were associated with changes in exercise behaviors. Our results highlight the importance of promoting physical activity guidelines for cancer survivorship during the COVID-19 pandemic and may help improve the identification of cancer patients susceptible to exercising less.

**Keywords** Exercise oncology · Covid-19 · Cancer prevention · Cancer epidemiology · Cancer survivorship

## Introduction

The COVID-19 pandemic has challenged healthcare in many ways by overwhelming healthcare capacities, delaying elective procedures, and overall, disrupting medical care [1–4]. Long-term impacts of the pandemic within many healthcare disciplines are expected to emerge over the next years or even decades. Within cancer care and prevention, the pandemic has led to delays or deferrals of cancer-related treatments, screening, and surveillance appointments [5–10]. For example, weekly colorectal cancer screenings drastically decreased by 86% in 2020 [6, 10, 11]. As a result, an

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increase in more advanced stage cancer cases is expected to emerge in the upcoming years.

Many behavioral factors including physical activity have been established as risk and prognostic factors of cancer [12–16]. Collective evidence shows that increased physical activity levels throughout the cancer care continuum may decrease the risk of disease and extend survival, particularly among breast and colon cancer patients [12–16]. The American College of Sports Medicine reports that by following these guidelines mortality rates of high incident cancer types (e.g., breast, colon, and prostate cancer) may be reduced by 40 to 50% [17, 18]. Physical activity after cancer diagnosis has further shown to improve overall quality of life, fatigue, sleep, mental health including depression and anxiety, and immune responses [19].

There is some evidence that the pandemic has led many individuals to change their health behaviors including physical activity levels and diet, potentially due to stay-at-home policies and closure of gyms [20–23]. Social isolation and COVID-19 restrictions may lead to physical inactivity among cancer survivors [24]. A recent study reported that physical activity levels measured in step counts significantly decreased within the general population since the start of the pandemic [20]. Another study in breast cancer survivors showed that 90% of the study population reduced their physical activity levels and increased the amount of sedentary behavior [25]. This study in breast cancer patients is the only study to date among individuals with cancer to examine changes in exercise behaviors due to the pandemic. However, their findings were limited by the small sample size ( $n = 37$ ).

In the present study, we investigate changes in exercise behaviors since the pandemic outbreak and identify risk/protective factors for decreased or increased physical activity among cancer patients and survivors. The results of this study will highlight the importance of promoting beneficial health behaviors, including exercise, among cancer patients and survivors especially during and post pandemic. Further, this work will allow clinicians and researchers to (1) know which subgroup of patients need early intervention to prevent decreased physical activity, and (2) identify modifiable targets for future interventions (e.g., social interactions).

## Methods

### Study design and participant selection

As part of the COVID-19 and Oncology Patient Experience Study (COPES) consortium,  $n = 1,400$  adult cancer patients ( $\geq 18$  years), who had visited Huntsman Cancer Institute (HCI) between 2016 and 2020 and were enrolled in the Total Cancer Care (TCC) study and the ColoCare Study (NCT02328677), completed a COVID-19 survey [26–28].

The majority of the patients at HCI completed the survey electronically, while some completed it in person or over the phone, between August and September 2020. Response rates ranged from 14 to 57%.  $n = 1,210$  patients diagnosed with stage I–IV cancers ( $n = 33$  with stage 0 were excluded), were 18 years and older ( $n = 4$  excluded  $< 18$  years old), and had data available on changes in exercise habits ( $n = 153$  with missing data on exercise habits or who exclusively reported “exercising in a different location than normal” were excluded), were included in the present work. The University of Utah Institutional Review Board (IRB) approved this protocol, and all participants provided written informed consent.

## Measures

### Outcome

**Exercise habits (health behavior)** A change in exercise habits was determined based on the following questions: ‘Since the COVID-19 pandemic began (March 2020), have your exercise habits changed?’ (yes or no) and ‘Since the COVID-19 pandemic began (March 2020), in what way have your exercise habits changed? Check all that apply’ (‘I do not exercise regularly’, ‘I am exercising less’, ‘I am exercising more’, ‘I am exercising in a different location than normal’, and ‘other’). Since the survey was administered between August and September 2020, the changes assessed in exercise habits were during the first 6 months of the pandemic (March to August/September 2020). Eighty-nine percent of patients ( $n = 1,247/1,400$ ), who participated in the survey completed the questions on changes in exercise habits. Patients were categorized into three groups: exercise less, i.e., patients who responded ‘I do not exercise regularly’ or ‘I am exercising less;’ exercise did not change, i.e., patients who responded ‘no’ change in exercise habits; and exercise more, i.e., patients who responded ‘I am exercising more.’ Patients who provided free-text responses under ‘other’ were categorized on an individual basis. However, patients who exclusively checked ‘I am exercising in a different location than normal’ were also excluded from the analyses.

### Exposures

**Demographic and clinical characteristics** Sociodemographic (sex, age at the time of survey, age at diagnosis, race, ethnicity) and clinical characteristics (tumor site, tumor stage) were abstracted from electronic medical records. Participants self-reported their height and weight, from which body-mass index was derived (BMI; if self-reported height and weight were missing, BMI was abstracted from medical records), current cancer patient status [patient has can-

cer and is currently receiving treatment, patient has cancer and has completed treatment, patient has cancer and came in for second opinion, or other (e.g., annual check-up after cancer remission, follow-up cancer care, IVIG treatment with cancer diagnosis, watch-and-wait, benign tumor diagnosis, and/or treatment after cancer)], COVID-19 infection status (positive COVID test within the past 6 months), and employment status. A measure of overall health status was adapted from the 12-item Short-Form Health Survey quality-of-life (QoL) measure [29]. Zip codes were categorized as urban or rural using the Rural–Urban Commuting Area Codes (RUCA) classification system [30].

**Other health behaviors** Smoking status was either self-reported (current or change in smoking status) or abstracted from medical records (ever smoker, i.e., at least 100 cigarettes in their lifetime). Patients also self-reported their alcohol consumption in the past year as well as change in alcohol consumption since the COVID-19 pandemic started.

**Psychosocial factors** Participants reported changes in daily life and financial stress in past month on a Likert scale from 1 (not at all) to 5 (a lot/very much) [31]. Changes in social interaction were reported by participants on a scale from 1 (much less social interaction) to 5 (a lot more social interaction), which was classified as participants reporting either: fewer social interactions, no change in social interactions, and more social interactions. A single item “How often have you felt lonely in the last month?” scored on a scale of 1 (never) to 5 (always) was adapted from the NIH Toolbox Loneliness instrument assessing perceptions of loneliness, which is an aspect of social relationships [32]. An item from the Perceived Stress Scale was used to assess perceived stress, asking “In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?” and scored on a scale of 1 (never) to 5 (often) [33, 34].

## Statistical analyses

Descriptive statistics (frequencies and percentages for categorical variables and mean and standard deviations for continuous variables) were performed for all variables of interest. One-way analysis of variance (ANOVA) for continuous variables and  $\chi$ -square tests for categorical variables were used to determine statistically significant differences ( $p < 0.05$ ) between the three exercise behavior groups (exercising less, exercise did not change, exercising more). Multivariate multinomial and binary logistic regression models were computed to identify the strongest predictors of changes in exercise habits. “Exercise did not change” was hereby used as reference category. The initial model included all statistically significant variables. Stepwise

backward selection was used to identify the strongest predictors. Any variables with a  $p$  value threshold of  $< 0.05$  remained in the model. Robustness of the model was tested using Hosmer and Lemeshow Goodness-of-Fit test. Statistical analyses were performed using SAS Software version 9.4.

## Results

### Patient characteristics

Table 1 summarizes the patient characteristics for  $n = 1,210$  cancer patients included in the present analyses. Mean age was 60 (range: 20–92) and 51% were female. Patients were on average 57 years old at the time of diagnosis. The average time since diagnosis was 4 years. Most patients had been diagnosed with breast ( $n = 179$ , 15%), gastrointestinal ( $n = 175$ , 14%), prostate ( $n = 177$ , 15%), or hematologic cancers ( $n = 231$ , 19%). Over half were diagnosed at stage I (36%) and II (25%). The patients had on average a BMI of 28.3 kg/m<sup>2</sup>. Most participants were residents from Utah and 27% lived in rural areas. About one-third of patients ( $n = 392$ , 32%) reported that they exercised less, while 121 (10%) patients exercised more during the pandemic. Over half of the study population (58%) reported to not have changed their exercise habits since the pandemic.

### Changes in exercise habits by demographic and clinical characteristics

Table 2 compares demographic and clinical characteristics by change in exercise habits. Patients who started exercising more during the pandemic were on average 6–8 years younger at the time of survey and at diagnosis (mean age: 54 and 50 years, respectively) as compared to those who exercised less (mean age: 60 and 56 years, respectively), or did not change their exercise habits (mean age: 62 and 58 years, respectively;  $p < 0.0001$ ). Male patients were less likely to exercise more (40% exercising more vs. 47% exercising less vs. 51% did not change exercise;  $p = 0.02$ ). Patients who were full-time employed were more likely to exercise more (48%;  $p = 0.0003$ ) than exercising less (30%) or not change their exercise habits (34%); while unemployed or retired patients were more likely to exercise less (62%) or maintain exercise habits (58%) as compared to exercise more (42%;  $p = 0.001$ ). Patients living in rural areas appeared to not change their exercise habits as compared to exercising less or more (32% vs. 21% or 19%;  $p < 0.0003$ ); on the other hand, a higher percentage of urban patients reported changes in their exercise habits, i.e., they either exercised less (79%) or more (81%).

**Table 1** Study population characteristics ( $n = 1,210$ )

Characteristics	$n$ (%) <sup>*</sup>
Age at the time of survey, mean $\pm$ SD (range)	60 $\pm$ 13 (20–92)
Age at diagnosis, mean $\pm$ SD (range)	57 $\pm$ 13 (18–89)
Years since diagnosis, mean $\pm$ SD (range)	4 $\pm$ 4 (0–37)
Sex	
Male	595 (49)
Female	615 (51)
Race	
White	1,155 (97)
Asian	11 (1)
American Indian or Alaska Native	11 (1)
Other	9 (1)
Ethnicity	
Hispanic/Latino	41 (3)
Non-Hispanic/Latino	1,091 (97)
Body Mass Index (BMI) (kg/m <sup>2</sup> ), mean $\pm$ SD	28.3 $\pm$ 6.35
Tumor site	
Breast	179 (15)
Gastrointestinal tract	175 (14)
Lung	36 (3)
Hematologic neoplasms	231 (19)
Melanoma	72 (6)
Prostate	177 (15)
Other	340 (28)
Tumor stage	
I	341 (36)
II	236 (25)
III	218 (23)
IV	155 (16)
Rural–urban status	
Rural	328 (27)
Urban	881 (73)
Employment status	
Employed full-time	412 (34)
Employed part-time	97 (8)
Not currently employed <sup>a</sup>	701 (58)
Had a COVID infection	
Yes	88 (7)
No	1,117 (93)
Changes in exercise habits	
Exercise less	392 (32)
No change in exercise habits	697 (58)
Exercise more	121 (10)

Data might not add to 100% because of rounding; Missing values due to skip patterns or non-response not shown (race:  $n = 24$ ; ethnicity:  $n = 78$ ; tumor stage:  $n = 260$ ; COVID infection:  $n = 5$ ; urban–rural status:  $n = 1$ )

<sup>\*</sup> $n$ (%) if not otherwise stated

<sup>a</sup>Includes patients who are retired

Changes in exercise habits due to the pandemic varied by tumor site ( $p = 0.01$ ). Patients diagnosed with lung cancer or hematologic neoplasms were more likely to increase exercise during the pandemic and less likely to maintain or decrease exercise, while patients diagnosed with gastrointestinal cancers were more likely to decrease exercise or maintain their exercise habits than increase exercise ( $p = 0.01$ ). Additionally, a higher proportion of patients with gastrointestinal cancers did not change their exercise habits compared to patients with breast cancer. Patients with stage IV cancer appeared to exercise more compared to exercise less or maintain exercise habits (26% vs. 16% or 15%;  $p = 0.008$ ). Those with very good to excellent health status exercised more (64%) in comparison with exercising less (39%) and no change in exercise habits (53%;  $p < 0.0001$ ). In contrast, 61% of those who reported to exercise less fell into either good or fair to poor health status categories. No differences were observed between the exercise groups when comparing patients' race, ethnicity, current cancer patient status, COVID infection status (i.e., whether they tested positive for COVID since March 2020), or BMI. Additionally, sensitivity analysis excluding patients who were actively undergoing treatment did not change our findings (results not shown).

### Changes in exercise habits by health behaviors

Table 3 compares health behaviors by changes in exercise habits. Changes in exercise habits differed by smoking status ( $p = 0.001$ ). Patients who were never smokers were more likely to start exercising more (81%) as compared to exercising less (77%) and no change (69%). Patients who never consumed alcohol in the past year were more likely to increase their exercise levels (59%) compared to exercising less (51%) and no changes in exercise behaviors (54%;  $p = 0.01$ ). Conversely, patients with the highest alcohol consumption (3–4 times a week to every day) either exercised less (18%) or did not change their exercise habits (16%) as compared to only 10% of those who exercised more ( $p = 0.01$ ). Change in alcohol consumption due to the pandemic was associated with changes in exercise habits ( $p = 0.008$ ). In particular, those who reported an increase in alcohol consumption due to the pandemic were also more likely to exercise less (7%) as compared to exercising more (4%) or reporting no change in their exercise habits (4%). Further, those who reported no change in alcohol consumption due to the pandemic were also more likely not to experience a change in their exercise habits (92%) as compared to exercising less (86%) or more (87%).

### Changes in exercise behaviors by psychosocial factors

Table 4 compares psychosocial factors by changes in exercise habits. The majority (60%) experienced a moderate

**Table 2** Demographic and clinical characteristics by changes in exercise habits ( $n = 1,210$ )

Characteristics	Exercising less ( $n = 392$ )*	No change in exercise habits ( $n = 697$ )*	Exercising more ( $n = 121$ )*	$p$ value <sup>a</sup>
Age at the time of survey				
Mean $\pm$ SD (range)	60 $\pm$ 11 (21–92)	62 $\pm$ 12 (22–92)	54 $\pm$ 13 (20–86)	< 0.0001
Age at diagnosis				
Mean $\pm$ SD (range)	56 $\pm$ 14 (18–89)	58 $\pm$ 12 (22–86)	50 $\pm$ 13 (19–77)	< 0.0001
Sex, $n$ (%)				
Male	184 (47)	363 (51)	48 (40)	0.02
Female	208 (53)	334 (49)	73 (60)	
Race, $n$ (%)				
White	374 (97)	667 (97)	114 (98)	0.23
Asian	5 (1)	6 (1)	0 (0)	
American Indian or Alaska Native	1 (0)	8 (1)	2 (2)	
Other	5 (2)	4 (1)	0 (0)	
Ethnicity, $n$ (%)				
Hispanic/Latino	11 (3)	26 (4)	4 (4)	0.50
Non-Hispanic/Latino	362 (97)	620 (96)	109 (96)	
Employment status, $n$ (%)				
Employed full-time	117 (30)	237 (34)	58 (48)	0.001
Employed part-time	27 (8)	57 (8)	13 (10)	
Not currently employed	248 (62)	403 (58)	50 (42)	
Urban–rural status, $n$ (%)				
Rural	82 (21)	223 (32)	23 (19)	0.0003
Urban	310 (79)	473 (68)	98 (81)	
Tumor site, $n$ (%)				
Breast	69 (18)	87 (12)	23 (19)	0.01
Gastrointestinal tract	52 (13)	117 (17)	6 (5)	
Lung	10 (3)	22 (3)	4 (5)	
Hematologic neoplasms	73 (18)	131 (19)	27 (22)	
Melanoma	20 (5)	45 (6)	7 (6)	
Prostate	48 (12)	115 (17)	14 (11)	
Other	120 (31)	180 (26)	40 (32)	
Tumor stage, $n$ (%)				
I	116 (39)	187 (33)	38 (41)	0.008
II	76 (26)	145 (26)	15 (16)	
III	56 (19)	146 (26)	16 (17)	
IV	49 (16)	82 (15)	24 (26)	
Current cancer patient status, $n$ (%)				
Have cancer and currently receiving treatment	130 (33)	224 (33)	28 (24)	0.59
Have cancer and completed cancer treatment	239 (63)	425 (62)	82 (69)	
Have cancer and came for 2nd opinion	4 (2)	9 (2)	2 (2)	
Other	8 (2)	12 (3)	4 (5)	
Had a COVID infection, $n$ (%)				
Yes	29 (7)	54 (8)	5 (4)	0.41
No	360 (93)	641 (92)	116 (96)	
Self-reported health status, $n$ (%)				
Very good to excellent	150 (39)	371 (53)	77 (64)	< 0.0001
Good	162 (41)	224 (32)	32 (26)	
Fair to poor	79 (20)	99 (15)	12 (10)	
BMI ( $\text{kg}/\text{m}^2$ )				
Mean $\pm$ SD	28.8 $\pm$ 6.40	28.1 $\pm$ 6.39	28.5 $\pm$ 6.52	0.08

Data might not add to 100% because of rounding; Missing values due to skip patterns or non-response not shown (race:  $n = 24$ ; ethnicity:  $n = 78$ ; tumor stage:  $n = 260$ ; COVID infection:  $n = 5$ ; urban–rural status:  $n = 1$ ; current cancer patient status:  $n = 43$ , self-reported health status:  $n = 4$ )

\* $n$ (%) if not otherwise stated

**Table 2** (continued)<sup>a</sup>Comparing three groups of changes in exercise habits**Table 3** Health behaviors by changes in exercise habits

Health behaviors	Exercising less ( <i>n</i> = 392)	No change in exercise habits ( <i>n</i> = 697)	Exercising more ( <i>n</i> = 121)	<i>p</i> value <sup>a</sup>
Current smoking status, <i>n</i> (%)				
Never	313 (77)	476 (69)	98 (81)	0.001
Former	65 (20)	193 (28)	20 (16)	
Current	11 (3)	18 (3)	2 (3)	
Alcohol consumption in past year, <i>n</i> (%)				
Never	189 (51)	319 (54)	66 (59)	0.01
Less than once a month	47 (14)	70 (11)	7 (6)	
Once a month to twice a week	58 (17)	110 (19)	29 (25)	
3–4 times a week to every day	60 (18)	104 (16)	13 (10)	
Change in alcohol consumption habits since COVID-19 pandemic, <i>n</i> (%)				
No	309 (86)	555 (92)	101 (87)	0.008
Yes, increased drinking	24 (7)	23 (4)	5 (4)	
Yes, decreased drinking	20 (7)	24 (4)	9 (9)	

Data might not add to 100% because of rounding; Missing values due to skip patterns or non-response not shown (current smoking status: *n* = 14; alcohol consumption in the past year: *n* = 138; change in alcohol consumption habits since COVID pandemic: *n* = 140)

<sup>a</sup>Comparing three groups of changes in exercise habits

amount or a lot of changes in their daily life due to the pandemic. Patients who reported ‘not at all’ or ‘a little bit’ change in daily lives were also more likely to report no changes in their exercise habits (25%) as compared to exercising less (7%) or more (15%;  $p < 0.0001$ ). Overall, most patients reported less social interactions in the past month (68%). Patients who reported more social interactions were more likely to exercise more as compared to exercising less or maintaining their exercise habits ( $p < 0.0001$ ). Feeling lonely, difficulties piling up, and financial stress in the past month had similar trends by the exercise groups. Patients who ‘never’ felt lonely, ‘never’ had difficulties piling up, or were ‘not at all’ financially stressed were also more likely not to experience changes in their exercise habits during the pandemic as compared to those exercising less or more ( $p < 0.0001$ ). Conversely, patients who regularly experienced loneliness, difficulties piling up, or financial stress also exercised less as compared to patients who exercised more or maintained their exercise habits ( $p < 0.0008$ ).

### Strongest predictors of changes in exercise habits

Tables 5 and 6, as well as Fig. 1 summarize multinomial and binary regression results using backward stepwise selection (variable remained with a  $p$  value threshold of  $< 0.05$ ). Age, tumor stage, health status, employment status, smoking status, and changes in daily life emerged as the strongest predictors. Those who started exercising less were more likely

to be not currently employed and reported ‘a lot’ of changes in daily life. Patients reporting ‘very good to excellent’ health status and ‘not at all’ or ‘a little’ change in daily life as well as former smokers were less likely to reduce exercise. Patients who started exercising more were younger, had stage IV disease, and reported ‘a lot’ of changes in daily life.

### Discussion

To the best of our knowledge, this is the first large study to investigate changes in exercise behaviors among cancer patients during the first 6 months of the COVID-19 pandemic as well as characteristics associated with these changes. A significant proportion of our study population experienced changes in exercise habits. Our results indicate that age, employment status, tumor stage, overall health status, smoking status, alcohol consumption, current patient status, and psychosocial factors were associated with changes in exercise behaviors during the pandemic. Specifically, one-third of our study population reported to have decreased the amount of regular exercise. This was more common among patients who were unemployed or retired, were not former smokers, and had poor health, and disruptions to daily life. In contrast, only a small proportion of our study population increased their exercise during the pandemic. Patient who increased exercise were younger and

**Table 4** Psychosocial factors by changes in exercise habits

Psychosocial factors	Exercising less ( <i>n</i> =392)	No change in exercise habits ( <i>n</i> =697)	Exercising more ( <i>n</i> =121)	<i>p</i> value <sup>a</sup>
Change in daily life due to pandemic, <i>n</i> (%)				
Not at all	4 (1)	43 (6)	3 (3)	<0.0001
A little bit	24 (6)	133 (19)	15 (12)	
Somewhat	73 (19)	173 (25)	18 (15)	
A moderate amount	115 (29)	191 (28)	34 (28)	
A lot	176 (45)	156 (22)	51 (42)	
Change in social interaction in past month, <i>n</i> (%)				
I have less social interaction	298 (76)	444 (64)	80 (67)	<0.0001
My social interaction has not changed much	79 (20)	214 (31)	24 (21)	
I have more social interaction	14 (4)	39 (5)	16 (12)	
Felt lonely in past month				
Never	93 (24)	277 (40)	39 (32)	<0.0001
Rarely	133 (34)	230 (33)	39 (32)	
Sometimes	134 (34)	156 (22)	33 (28)	
Usually	25 (6)	28 (4)	9 (7)	
Always	7 (2)	5 (1)	1 (1)	
Difficulties piling up that could not be overcome in past month, <i>n</i> (%)				
Never	127 (32)	356 (51)	45 (37)	<0.0001
Almost never	128 (33)	185 (27)	45 (37)	
Sometimes	105 (27)	109 (16)	21 (17)	
Fairly often	22 (6)	33 (5)	9 (7)	
Often	10 (3)	12 (2)	1 (1)	
Financially stressed in past month, <i>n</i> (%)				
Not at all to a little bit	300 (77)	571 (82)	97 (80)	0.0008
Somewhat	43 (11)	60 (9)	13 (11)	
Quite a bit to very much	48 (12)	66 (9)	11 (9)	

Data might not add to 100% because of rounding; Missing values due to skip patterns or non-response not shown (change in daily life due to pandemic: *n*=1; change in social interaction in past month: *n*=2; felt lonely in past month: *n*=1; difficulties piling up that could not be overcome in past month: *n*=2; financially stressed in past month: *n*=1)

<sup>a</sup>Comparing three groups of changes in exercise habits

had more advanced stage cancer and disruptions to their daily lives.

A reduction in exercise is especially concerning in the cancer population given the strong evidence of beneficial effects of physical activity on survivorship [12–16, 19, 35]. Physical activity before and after cancer diagnosis has been shown to have substantial health benefits for cancer patients [12–16, 19, 35]. Physical activity not only reduces the risk of cancer but can also improve cancer outcomes, including survival and recurrence. [12–16, 19, 35]. Further, physical activity enhances overall quality of life and physical function particularly among individuals with cancer, and may improve other potential comorbidities including diabetes, cardiovascular, or respiratory diseases [19]. Although not explicitly asked in this study, challenges in accessing exercise facilities, being at high risk of having poor outcomes if exposed to COVID-19 infection, or finding motivation to

exercise due to stay-at-home policies may have contributed to the substantial decrease in exercise activities observed in this study.

Our study provides further support for prior research before the pandemic highlighting the barriers to exercise and determinants of exercise adherence among cancer survivors [36, 37]. Younger cancer survivors are oftentimes more active, while older cancer survivors often engage in less activity due to underlying health conditions, a higher prevalence of overweight and obesity, and cancer treatment-related side effects such as fatigue and pain [37]. Among cancer patients, adherence to exercise interventions does not appear to be influenced by sex, although the data remains inconclusive [36]. Our results support these findings indicating that sex is not a strong predictor of changes in exercise habits. In alignment with previous studies showing that employed individuals spend more time in moderate

**Table 5** Multinomial logistic regression: Clinicodemographic, health behavioral, and psychosocial predictors of changes in exercise behavior

	Exercising less vs. no change OR (95% CI)	Exercising more vs. no change OR (95% CI)	<i>p</i> value
Clinicodemographic characteristics			
Age			
Age at the time of survey (years)	1.00 (0.98–1.01)	<b>0.96 (0.94–0.98)</b>	<b>0.002</b>
Tumor stage			
I	–	–	<b>0.01</b>
II	0.90 (0.59–1.37)	0.61 (0.30–1.22)	
III	0.69 (0.43–1.10)	0.78 (0.38–1.58)	
IV	1.08 (0.66–1.75)	<b>2.28 (1.21–4.31)</b>	
Self-reported health status			
Very good to excellent	<b>0.48 (0.29–0.80)</b>	1.64 (0.67–4.02)	<b>0.0003</b>
Good	0.96 (0.58–1.60)	1.32 (0.52–3.35)	
Fair to poor	–	–	
Health behaviors			
Current smoking status			
Never	–	–	<b>0.001</b>
Former	<b>0.38 (0.24–0.59)</b>	0.89 (0.46–1.72)	
Current	1.12 (0.38–3.36)	2.10 (0.40–11.0)	
Psychosocial factors			
Change in daily life due to pandemic			
Not at all	–	–	<b>&lt; 0.0001</b>
A little bit	1.35 (0.34–5.33)	1.34 (0.32–5.70)	
Somewhat	<b>3.90 (1.10–13.9)</b>	<b>1.07 (1.10–4.33)</b>	
A moderate amount	<b>3.76 (1.06–13.3)</b>	1.56 (0.39–6.20)	
A lot	<b>9.93 (2.79–34.6)</b>	3.59 (0.92–14.1)	

Predictors remained in the model if  $p < 0.05$ ; OR—odds ratio, 95% CI—95% confidence interval; bold indicates statistical significance ( $p < 0.05$ )

and vigorous physical activity [38, 39], full-time employed patients in our study population were more likely to increase their activity levels since the start of the pandemic. Greater opportunities to work out while working from home and less time spent commuting may explain this observation. On the contrary, unemployed patients may be retired and older or may have lost job due to the pandemic and, hence, less active. Consistent with prior research [40, 41], urban patients in our study experienced more changes in their exercise habits due to the pandemic, potentially due to stay-at-home policies, closure of gyms, or more time to workout [42, 43]. However, rural–urban status was not identified as a strong predictor of changes in exercise habits.

Although tumor site was not a strong predictor of changes in exercise habits, our study suggests that patients diagnosed with breast cancer, lung cancer, or hematologic neoplasms were more likely to increase exercise during the pandemic, while patients diagnosed with gastrointestinal and prostate cancers were more likely to maintain exercise than increase or decrease it. Notably, patients with gastrointestinal cancers as compared to breast cancers, for which

physical activity is an established protective factor, were less likely to exercise more. This aligns with studies conducted before the pandemic showing reduced engagement in physical activity among patients with gastrointestinal cancer [44, 45]. Our data suggest that patients diagnosed with stage IV disease tend to exercise more and was a strong predictor of change in exercise habits, independent of whether patients were currently undergoing active cancer treatment. Exercise may be a mechanism for these patients to cope with the high burden of treatment- and disease-related side effects.

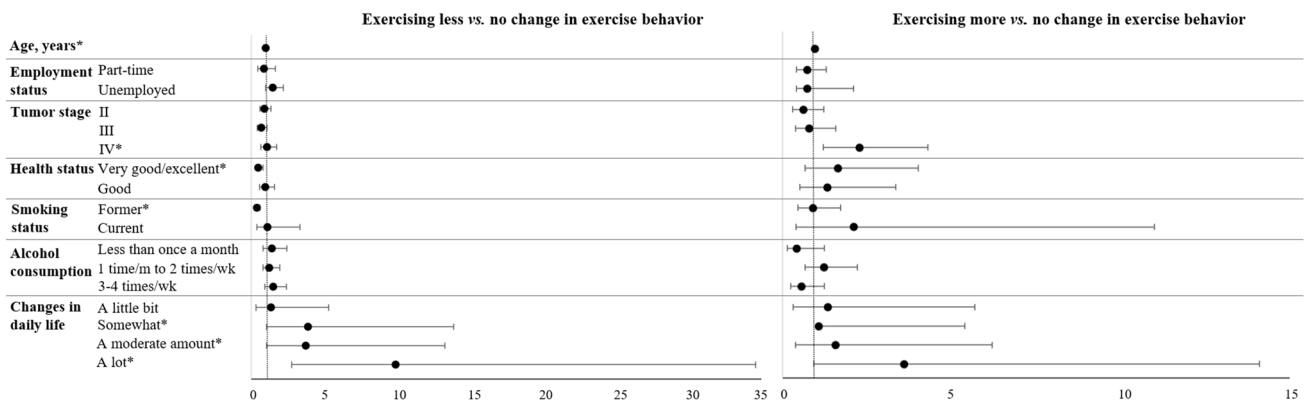
Patients following other healthy lifestyle behaviors such as never smoking, never drinking alcohol, or decreasing alcohol consumption during the pandemic were more likely to exercise more, which is consistent with previous studies [47]. Individuals who fall into an overall ‘healthier’ lifestyle cluster considering smoking, nutrition, alcohol, and physical activity, are generally more active [47]. Overall, our data suggest that the pandemic contributed to the factors that have been previously identified as barriers to exercise,



**Table 6** Strongest predictors of changes in exercise habits selected from a backward stepwise binary logistic regression

	OR (95% CI)	<i>p</i> value
<b>Exercising less vs. exercise did not change</b>		
Self-reported health status		
Very good to excellent vs. fair to poor/good	0.59 (0.36–0.71)	< 0.0001
Employment status		
Not currently employed vs. employed full-time/part-time	1.48 (1.05–2.08)	0.03
Current smoking status		
Former vs. never/current	0.39 (0.25–0.60)	< 0.0001
Change in daily life due to pandemic		
Not at all vs. a little bit/somewhat/a moderate amount/a lot	0.27 (0.08–0.94)	0.04
A little bit vs. not at all/somewhat/a moderate amount/a lot	0.40 (0.19–0.71)	0.003
A lot vs. not at all/a little bit/somewhat/a moderate amount	2.54 (1.78–3.62)	< 0.0001
<b>Exercising more vs. exercise did not change</b>		
Age		
Age at the time of survey (years)	0.95 (0.96–0.97)	< 0.0001
Tumor stage		
IV vs. I/II/III	2.41 (1.37–4.24)	0.002
Change in daily life due to pandemic, <i>n</i> (%)		
A lot vs. not at all/a little bit/somewhat/a moderate amount	3.30 (2.35–4.62)	0.0002

Predictors remained in the model if *p* < 0.05; OR—odds ratio, 95% CI—95% confidence interval; bold indicates statistical significance (*p* < 0.05)



**Fig. 1** Forest plot (multinomial logistic regression) testing associations between clinicodemographic, health behavioral, and psychosocial predictors with changes in exercise behavior. Reference groups: employment status—full-time employed; tumor stage—stage I; health

status—fair to poor; smoking status—never; alcohol consumption—never; changes in daily life—not at all. *m* month, *wk* week. \*Indicates statistical significance (*p* < 0.05)

resulting in less exercise during the pandemic among a significant proportion of cancer patients and survivors.

Strong evidence supports exercise as a coping mechanism for side effects of cancer, its treatment, and related behavioral health challenges including anxiety, depression, fatigue, and sleep difficulties [48–50]. Research also shows that individuals with underlying mental health problems, perceived stress, or financial hardship engage in less physical activity [51–53]. The pandemic has caused the majority of individuals to experience increased levels of stress and anxiety as well as financial difficulties due to loss of

employment, income, or health insurance [8, 54]. In addition, social distancing policies and other restrictions to prevent the spread of the virus have reduced the ability to cope with underlying mental health conditions. A recent study reported that individuals who remained active or increased their activity levels during the pandemic have done so to maintain their mental health [55]. In contrast, mental health conditions associated with the pandemic have emerged as barriers to exercise [55]. Our results confirm these findings within the cancer population. In particular, patients who had more changes in their daily lives, felt lonely, had fewer social

interactions, were financially stressed, and experienced perceived stress in terms of difficulties piling up appeared more likely to exercise less and less likely to engage in more exercise, although only changes in daily life was identified as a key factor. These results elucidate the need to screen for mental health and financial challenges faced by cancer survivors during the pandemic and promote psychosocial programs that address unique needs and challenges within this population.

This study has several strengths and limitations. Exercise habits were self-reported and may be subject to recall bias. However, given the timeliness of the pandemic, the conscious perception of changes in life experienced by many, and prospective design of the study, we assume that patients can more easily recall any behavioral changes. Additionally, no data on baseline physical activity levels were available, which would have been helpful to understand the context of adherence to physical activity guidelines. Survey responses may have been biased by the type of survey (in person, phone, electronically), although most patients completed electronic surveys. The majority of the study population was White, non-Hispanic/Latino, and from Utah. Thus, the generalizability of our results may be limited and not applicable to those with different racial and ethnic backgrounds, or those from other states who may have had different COVID-19 state-wide policies. However, our study population included a significant proportion from rural residents (27%) making the results more applicable for other states with similar urban–rural proportions. The response rate was moderate and may have introduced selection bias. Lastly, future large-scale studies should expand on our results conducting stratified analyses by tumor type.

The pandemic has impacted everyone's lives in many ways including changes in health behaviors. Health behaviors such as being physically active are even more important for immune compromised populations like cancer survivors. Our results indicate that many cancer patients and survivors reduced their exercise during the first 6 months of the pandemic. This was more common among patients who were unemployed or retired, had poor health, and increased levels of psychosocial stressors such as disruptions to daily life. This study identified risk factors for changes to physical activity among cancer patients and survivors as well as highlights targets for future interventions to prevent reduced physical activity and promote increased exercise.

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**Data availability** The data presented in this study are available in this article. Restrictions apply to the availability of supporting data to protect the privacy of participants.

## Declarations

**Conflict of interest** Dr. Ulrich has as Executive Director of the Comprehensive Cancer Center at Huntsman Cancer Institute oversight over research funded by several pharmaceutical companies but has not received funding directly herself. Dr. Tward has served on an advisory board and consulted for Myriad Genetics, Inc., Decipher Biosciences, and Boston Scientific; he has received research funding from Bayer for work outside of the present manuscript. Dr. Lee has served on advisory boards and/or consulted for Jazz Pharmaceuticals, Kite Pharma, Kadmon Corporation, Fresenius Kabi, and CareDx; she has received research funding from Incyte for work outside of the present manuscript. Dr. Gonzalez has served on advisory boards and/or consulted for SureMed Compliance, Elly Health, and KemPharm. Other authors declare that they have no conflict of interest.

**Ethical approval** The University of Utah Institutional Review Board (IRB) approved this protocol.

**Consent to participate** All participants provided written informed consent.

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