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ORIGINAL PAPER

Correlates of poor adherence to a healthy lifestyle among a diverse group of colorectal cancer survivors

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Abstract

Purpose Lifestyle factors may have a synergistic effect on health. We evaluated the correlates of poor adherence to a healthy lifestyle among a diverse sample of colorectal cancer (CRC) survivors to inform future lifestyle promotion programs.

Methods Lifestyle questions from a cross-sectional survey were completed by 283 CRC survivors (41% Hispanic, 40% rural, 33% low income). Adherence to recommendations (yes/no) for physical activity, fruit and vegetable servings/day, avoiding tobacco, and healthy weight was summed to create an overall lifestyle quality score. Polytomous logistic regression was used to evaluate correlates of good (reference group), moderate, and poor overall lifestyle quality. Potential correlates included sociodemographic characteristics, cancer-related factors, and indicators of health and well-being.

Results CRC survivors with poor adherence were 2- to 3.4-fold significantly more likely to report multiple comorbidities, poor physical functioning, fatigue, anxiety/depressive symptoms, and poor social participation. In multivariable analyses, poor physical functioning was the only significant correlate of poor adherence to lifestyle recommendations, compared to good adherence [OR (95% CI) 3.4 (1.8–6.4)]. The majority of survivors, 71% and 78%, indicated interest in receiving information on exercise and eating a healthy diet, respectively.

Conclusion Future lifestyle promotion programs for CRC survivors should carefully consider indicators of physical and psychosocial health and well-being, especially poor physical functioning, in the design, recruitment, and implementation of these health programs.

Keywords Cancer survivors · Colorectal cancer · Physical activity · Diet · Rural · Lifestyle behaviors · Modifiable risk factors

Introduction

As of 2016, there were more than 1.45 million colorectal cancer (CRC) survivors living in the USA [1]. This number is expected to increase to 1.8 million by the year 2026 [1]. Since 58% of CRC patients are living 10 years or longer beyond their diagnosis [1], preventive health is an important aspect of cancer survivorship [2]. CRC survivors are at increased risk of cancer recurrence [3, 4], second malignancies [5], and chronic health conditions associated with aging and cancer treatments [6–9]. Adherence to a healthy lifestyle can prevent, delay, or attenuate these adverse health outcomes. While a cancer diagnosis is considered a "teachable moment" for improving lifestyle behaviors associated with health and well-being [10], a large proportion of cancer survivors do not adhere to guidelines for a healthy lifestyle [11–13].

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Guidelines for cancer prevention [14, 15] and, recently, for cancer survivorship [16–18] provide recommendations for adherence to a healthy lifestyle for cancer survivors. These guidelines encourage cancer survivors to achieve and maintain a healthy lifestyle through weight management, regular physical activity, eating a healthy diet, limiting alcohol consumption, and avoiding tobacco products. Non-adherence to these recommendations has been associated with increased risk of other malignancies, diabetes, cardiovascular disease, disability, and premature mortality [19–22]. CRC survivors are at increased risk for cardiovascular disease and diabetes [23]. Furthermore, CRC has the second highest number of deaths (nearly 30,000 per year) in the USA that is attributable to potentially modifiable lifestyle factors [24]. Given the lengthy survivorship period for many CRC survivors, it is important to promote a healthy lifestyle to help improve their health and well-being and to reduce their risk of adverse health outcomes.

The majority of studies among cancer survivors have evaluated the correlates of adherence to individual health behaviors (or lifestyle factors). However, the number of (un) healthy lifestyle factors may have a synergistic effect on health outcomes, i.e., the effect may be multiplicative rather than additive [12, 25, 26]. Therefore, recently, there has been an interest in examining adherence to multiple lifestyle recommendations among CRC survivors as an indicator of overall lifestyle quality [12, 27–29]. Accumulating evidence suggests that adherence to a greater number of healthy lifestyle factors is associated with better health-related quality of Life (QOL) [12, 27–29] and reduced cancer-specific and all-cause mortality [19, 20, 30]. Thus, identifying CRC survivors most in need of lifestyle improvement is important for informing the design and implementation of lifestyle improvement programs.

Less is known about the prevalence and correlates of adherence to multiple lifestyle factors (aka overall lifestyle quality) in CRC survivors from health disparities populations [31] (e.g., racial/ethnic minority, rural, lower income). While the association between individual lifestyle factors and better health-related QOL among cancer survivors is well established, less is known about the role QOL factors play in identifying CRC survivors with the lowest overall lifestyle quality. Additionally, identifying factors associated with CRC survivors' interest in learning about eating healthy and/or exercising regularly is necessary to inform interventions in these under-represented populations. Utilizing data from a cross-sectional study, the objectives of this study were to: (1) describe the prevalence of the overall lifestyle quality among an ethnically, economically, and geographically diverse group of CRC survivors; (2) identify sociodemographic characteristics, cancer-related factors, and indicators of health and QOL that are associated with poor adherence to multiple lifestyle recommendations; and (3) identify correlates associated with CRC survivors' interest in obtaining information on achieving a healthy lifestyle. Results from this study may inform future lifestyle promotion programs for a diverse CRC survivor population.

Methods

Study design and participants

The New Mexico Colorectal Cancer Survivor Project was a cross-sectional study designed to assess survivorship issues among a diverse sample of CRC survivors in New Mexico. The design and methods have been previously reported [32]. Briefly, eligibility criteria included a diagnosis of stage I–III colon or rectal cancer diagnosis within the past ten years, aged 30 to 74 years of age, and a resident of New Mexico (NM) at the time of diagnosis. The New Mexico Tumor Registry (NMTR), a founding member of the Surveillance, Epidemiology, and End Results Program, identified 924 CRC survivors diagnosed between 2004 and 2012 across the state of NM. Hispanic and rural cancer survivors were oversampled with a goal of achieving a similar distribution of study participants based on ethnicity and rural–urban residence. The mailed questionnaire included items about CRC screening, lifestyle behaviors, medical history, and physical, emotional, and psychosocial health and well-being. The investigation was approved by the Human Research Review Committee at the University of New Mexico Health Sciences Center.

Outcomes and measures

Lifestyle Factors. Questions pertaining to lifestyle factors included height, weight, cigarette smoking, fruit and vegetable intake, and physical activity. Self-reported height and weight were used to calculate BMI. Since overweight status (BMI 25.0–29.9 kg/m^2) has been associated with longer survival among CRC survivors [19, 33], and few study participants were underweight, we dichotomized BMI by obesity, similar to other studies [29]. Specifically, obesity was defined as BMI $\geq$ 30 kg/m^2; BMI between 18.5 and 29.9 kg/m^2 served as the reference category [34]. Smoking status was categorized as never, former, or current smoker. Two questions assessed the average number of servings per day of fruit (not including juice) and vegetables (not including potatoes) in the past month. Recreation, sport, and leisure-time physical activity questions from the International Physical Activity Questionnaire (IPAQ) were used to assess the frequency and duration of moderate physical activity (examples include: carrying light loads, bicycling at regular pace, doubles tennis) and vigorous physical activity (examples

include: heavy lifting, digging, aerobics, fast bicycling) [35]. The frequency of walking for at least 10 min was assessed separately, and included walking at work, at home, for transportation, and for recreation, sport or exercise. Adherence to physical activity guidelines was defined as 150 min per week of moderate-intensity or 75 min per week of vigorous-intensity activity. Walking was assumed to be a moderate-intensity activity [36].

Unhealthy lifestyle factors included obesity, current smoking, consuming fewer than 5 fruit and vegetable servings per day (proxy for poor diet), or being physically inactive (not meeting physical activity guidelines). The number of unhealthy lifestyle factors was summed to create a lifestyle score, similar to other studies [27–29], representing overall lifestyle quality. Due to small cell sizes for the lowest and highest number, the lifestyle score was categorized as low risk (0–1 unhealthy lifestyle factors), moderate risk (2 unhealthy lifestyle factors), or high risk (3–4 unhealthy lifestyle factors). Individuals who could not be categorized due to missing data were excluded from the analyses ($n = 18$).

Potential correlates of overall lifestyle quality

Factors evaluated as potential correlates of overall lifestyle quality (i.e., number of (un)healthy lifestyle factors) and interest in healthy lifestyle included sociodemographic characteristics, cancer-related factors, and physical, mental, and psychosocial indicators of health and well-being.

Sociodemographic characteristics

Individuals self-identified as Hispanic/Latino(a). Education was dichotomized as less than or equal to high school graduate vs. any additional vocational or college experience. Living arrangement was categorized as living alone (single, separated, divorced, widowed, never married) vs. not living alone (married, member of an unmarried couple). The Rural Urban Commuting Area (RUCA) codes were used to classify rural–urban status based on zip code at the time of study enrollment [37]. Urban was defined using the metropolitan area codes (1–3); rural was defined using the large rural, small rural, and isolated rural codes (4–11) [38]. Both income category (<$15,000, $15,000–$29,999, $30,000–$49,999, $50,000–$69,999, $70,000–$99,999, $100,000, or more) and the number of individuals supported by that income were assessed. The 2015 poverty guidelines for the 48 contiguous states were used to calculate 200% above poverty level using the median value of each income category and the number of household individuals [39].

Cancer-related factors

Cancer-related factors included stage of disease, time since diagnosis (years), number of cancer-related symptoms, and worry about recurrence or another cancer. The FACT-C (version 4) CRC subscale includes seven items related to CRC symptoms (Cronbach's alpha 0.85 to 0.91) [40]. Scores range from zero (highest impact due to symptoms) to 28 (no impact due to symptoms). Greater concern with CRC-related symptoms was defined as scores < 18, representing one-third of the study population. The frequency and intensity of worry "about getting colorectal cancer again" or "getting another type of cancer" were each assessed with a 3-item scale [41]. Reliability of the worry scale is good (Cronbach's alpha 0.68 to 0.77) [42, 43].

Measures of physical and psychological health and well-being

General health was assessed with a single question and categorized as either excellent, very good, or good, versus fair or poor. Participants responded (yes/no) to health professional diagnosed medical conditions either that are associated with an increased risk of CRC or that are common among CRC survivors. The number of comorbidities (prediabetes or diabetes, asthma, arthritis, depression, hypertension, heart attack or congestive heart failure, chronic obstructive pulmonary disease, or chronic bronchitis) was summed and categorized as < 2 vs. ≥ 2. The PROMIS-29 questionnaire was used to assess health-related QOL. The PROMIS-29 is comprised of seven domains (physical function, depression, anxiety, fatigue, sleep disturbance, pain interference, and satisfaction with participating in social roles and activities). Each domain includes four questions, each with five response options. To facilitate translation, variables were dichotomized to indicate poor QOL based on a t-score > 0.5 standard deviations (SD) below the population mean (worse score). A one-half SD represents the minimally clinically important difference for QOL [44].

Interest in more information on diet and physical activity

The questionnaire also included two items regarding the level of interest in getting more information on exercise and on eating a healthy diet. Response items included definitely not interested, somewhat interested, and very interested. Additional questions assessed the best time to receive advice about exercise or eating a healthy diet. Response items

included before treatment, during treatment, immediately after treatment, 3–6 months after treatment, at least 1 year after treatment, or all of the above.

Statistical analyses

Descriptive statistics were used to describe sociodemographic characteristics, cancer-related factors, and indicators of health and well-being associated with non-adherence to individual lifestyle recommendations and as categories based on overall lifestyle quality score. Non-proportional polytomous logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for correlates of the low-, moderate-, and high-risk groups based on the number of lifestyle risk factors (aka unhealthy lifestyle factors). The low-risk group (0–1 lifestyle risk factors) served as the reference category. First, unadjusted analyses were conducted to examine the association between lifestyle risk factors and potential correlates (sociodemographic characteristics, cancer-related factors, measures of health and well-being). Second, multivariable analyses were conducted to identify significant independent correlates. The chi-square test was used to evaluate correlates of interest in information on eating a healthy diet among CRC survivors not meeting dietary guidelines. Individuals who responded somewhat or very interested were compared to those who were definitely not interested. Similar analyses were conducted for interest in receiving information on exercise. Statistical analyses were conducted using SAS 9.4 statistical software (SAS Institute, Inc.). To account for multiple comparisons, the Benjamini–Hochberg Procedure was used to decrease the false discovery rate to 5% [45]. p values smaller than the Benjamini–Hochberg critical value of 0.0175 were considered statistically significant.

Results

Characteristics of colorectal cancer survivors

The survey was completed by 301 CRC survivors. The contact rate (percentage contacted by telephone) was 57.5%, the cooperation rate (percentage enrolled in the study of those who were contacted) was 62%, and the response rate was 32.6%. Ninety-four percent ($n=283$) of survivors completed questions on lifestyle factors and thus were included in this analysis. Among the 283 CRC survivors, the mean (SD) age was 62.8 (SD = 7.7) years, 52% were male, 41% reported Hispanic ethnicity, 40% resided in a rural area, and 33% had a household income that was less than 200% of the federal poverty level. The median time between CRC diagnosis and survey completion was 6.0 years (range 2 to 14 years), 32% were diagnosed with regional-stage disease, and 76% were either worried about a recurrence or another cancer. Nearly half of the survivors had 2 or more comorbidities, and 26% reported fair or poor general health.

Non-adherence to individual lifestyle recommendations

Non-adherence to individual healthy lifestyle factors was as follows: 37% obese, 22% currently smoking, 32% physically inactive, and 72% eating fewer than five fruit and vegetable servings per day (Table 1). Cancer survivors who were obese were more likely to be younger (<60 years), have multiple comorbidities, report fair or poor general health, and have poor physical functioning, fatigue, and poor satisfaction with social roles and activities. Current smokers were more likely to report Hispanic ethnicity, less education, low household income, and have poor physical functioning, depressive symptoms, anxiety symptoms, and greater concerns about CRC-related symptoms. Cancer survivors not meeting guidelines for fruit and vegetable servings/day (proxy for poor diet) were more likely to be male and non-Hispanic white and to have more education and higher household income. However, in a multivariable model including all sociodemographic characteristics, the only significant correlates of poor diet were ethnicity (non-Hispanic) and sex (males). Survivors not meeting physical activity guidelines were more likely to report a low household income, depressive symptoms, and poor physical health (multiple comorbidities, fair/poor general health, poor physical functioning, and fatigue).

Characteristics of cancer survivors according to number of unhealthy lifestyle factors

Among 283 CRC survivors, half had zero or one unhealthy lifestyle factor (low-risk group), 29% had two (moderate-risk group), and 21% had three or four (out of four; high-risk group) unhealthy lifestyle factors. There were no significant associations between sociodemographic characteristics or cancer-related factors and the number of lifestyle risk factors (Table 2). Survivors with poor health, or poor physical, mental, or psychosocial QOL were significantly more likely to be in the high-risk group ($0.001 \leq p$ values ≤ 0.014).

Non-adherence to multiple healthy lifestyle factors (overall lifestyle quality)

In unadjusted analyses, CRC survivors in the moderate-risk group (two out of four unhealthy lifestyle factors) were 1.8 to 1.9 times more likely to report poor physical functioning and fair or poor general health, respectively, compared to survivors in the low-risk group (zero or one unhealthy lifestyle

Table 1 Non-adherence to individual lifestyle recommendations among a diverse sample of colorectal cancer survivors

	Unhealthy lifestyle factors				
	% Obese	% Current smoker	% Poor diet	% Physically inactive	# of unhealthy lifestyle factors Mean ± SD
Demographic factors					
Age (years)					
< 60 (n = 91)	**46.2**	28.9	62.6	29.2	1.6 ± 1.0
60–66 (n = 94)	**34.0**	22.3	77.7	31.9	1.7 ± 1.0
> 66 (n = 98)	**28.9**	16.3	74.5	34.7	1.6 ± 0.9
Sex					
Male (n = 149)	32.2	20.8	**78.5**	29.5	1.6 ± 0.9
Female (n = 134)	40.6	24.1	**64.2**	34.9	1.6 ± 1.1
Ethnicity					
Hispanic (n = 117)	42.2	**28.5**	**59.0**	32.1	1.6 ± 1.0
Non-Hispanic (n = 166)	31.9	**18.1**	**80.7**	31.9	1.6 ± 1.0
Residence					
Rural (n = 112)	37.5	25.0	75.9	36.4	**1.8 ± 1.0**
Urban (n = 171)	35.3	20.6	69.0	29.2	**1.5 ± 1.0**
Education					
≤ High School or GED (n = 75)	41.3	**33.8**	**60.0**	37.0	1.7 ± 1.0
Beyond High School (n = 207)	34.0	**18.4**	**75.9**	30.4	1.6 ± 1.0
Household income					
Low (n = 92)	39.6	**37.4**	**63.0**	**41.1**	1.8 ± 1.1
Moderate to High (n = 173)	34.1	**13.9**	**75.7**	**27.7**	1.5 ± 0.9
Living arrangement					
Not alone (n = 186)	35.5	20.0	74.7	30.1	1.6 ± 1.0
Alone (n = 95)	36.2	27.4	66.3	35.5	1.6 ± 1.0
Employment status					
Employed (n = 110)	42.7	19.3	70.9	30.3	1.6 ± 1.0
Retired (n = 120)	28.6	20.8	75.0	29.7	1.6 ± 0.9
Other (n = 52)	38.5	32.7	65.4	42.0	1.7 ± 1.1
Cancer-related factors					
Stage					
Early (I–II) (n = 192)	**32.3**	22.5	72.9	31.6	1.6 ± 1.0
Late (III) (n = 91)	**44.4**	22.0	69.2	33.0	1.7 ± 1.0
Time since diagnosis					
≤ 5 years (n = 130)	36.2	27.1	73.9	33.1	1.7 ± 1.0
> 5 years (n = 153)	36.2	18.3	69.9	31.1	1.6 ± 1.0
Worry about recurrence/another cancer					
No (n = 66)	42.4	18.2	75.8	34.9	1.7 ± 1.0
Yes (n = 215)	34.1	23.8	70.7	31.4	1.6 ± 1.0
Major concerns about cancer-related symptoms					
No (n = 197)	35.2	**18.9**	73.1	29.7	1.6 ± 0.9
Yes (n = 83)	38.6	**31.3**	67.5	37.5	1.7 ± 1.1
Health and QOL indicators					
Number of comorbidities					
< 2 (n = 143)	**28.0**	18.3	74.8	**25.7**	**1.5 ± 0.8**
≥ 2 (n = 140)	**44.6**	26.4	68.6	**38.4**	**1.8 ± 1.1**
General health					
Good, very good or excellent (n = 207)	**31.9**	21.4	73.0	**24.9**	**1.5 ± 0.9**
Fair or poor (n = 73)	**47.2**	24.7	68.5	**51.4**	**1.9 ± 1.0**

Table 1 (continued)

	Unhealthy lifestyle factors				
	% Obese	% Current smoker	% Poor diet	% Physically inactive	# of unhealthy lifestyle factors Mean ± SD
Poor physical functioning					
No ($n=174$)	**30.5**	**17.3**	74.1	**21.5**	**1.4 ± 0.9**
Yes ($n=107$)	**45.3**	**29.9**	67.3	**48.1**	**1.9 ± 1.0**
Depressive symptoms					
No ($n=189$)	35.1	**18.1**	72.5	**26.7**	**1.5 ± 0.9**
Yes ($n=89$)	38.2	**30.3**	70.8	**43.0**	**1.8 ± 1.0**
Anxiety symptoms					
No ($n=190$)	36.0	**16.8**	72.6	28.7	1.6 ± 0.9
Yes ($n=88$)	36.4	**32.2**	69.3	38.8	1.7 ± 1.1
Fatigue					
No ($n=197$)	**29.4**	19.9	74.6	**27.2**	**1.5 ± 0.9**
Yes ($n=78$)	**49.4**	28.2	65.4	**45.3**	**1.9 ± 1.1**
Poor satisfaction—social roles and activities					
No ($n=177$)	**31.6**	18.8	74.0	**24.6**	**1.5 ± 0.9**
Yes ($n=104$)	**44.7**	27.9	68.3	**44.6**	**1.9 ± 1.1**
Pain interference					
No ($n=154$)	35.7	18.3	76.0	27.0	1.6 ± 1.0
Yes ($n(n=126$)	36.8	27.0	65.9	37.4	1.7 ± 1.0

Percentages and means ± SD in bold are statistically significant ($p<0.05$)

factors; reference group; Table 3). However, compared to the reference group, CRC survivors in the high-risk group were twice as likely to report anxiety or depressive symptoms; two and one-half times more likely to report fatigue or poor social participation; and three times as likely to report fair/poor health, multiple comorbidities, and poor physical functioning. In multivariate analyses, the only statistically significant ($p<0.05$) correlate of the number of unhealthy lifestyle factors (high-risk group vs. low-risk group) was poor physical functioning.

Interest in receiving information on a healthy lifestyle

Among CRC survivors not meeting physical activity guidelines, 71% were interested in receiving information on exercise. While the majority (61%) did not have a preference for the best time to receive advice on exercise, 21% preferred sometime after completing treatment; 13% preferred before cancer treatment, and only 5% preferred during treatment. The only correlate of interest in receiving information about exercise was time since diagnosis (greater interest among long-term (>5 years since diagnosis) CRC survivors) (Table 4). In our study, nearly three-fourths of CRC survivors did not meet the recommended amount of five or more servings of fruits and vegetables per day. Among those who were non-adherent, 78% were interested in receiving information on eating a healthy diet. The majority (69%) did not have a preference for the best time to receive advice on a healthy diet, whereas the preferred time to receive this advice was 14% after cancer treatment, 14% before cancer treatment, and only 3% during treatment. Significant correlates of interest in receiving information about eating a healthy diet were anxiety or depressive symptoms and fatigue. When asked about participating in a new dietary intervention that could possibly reduce their risk of getting cancer again, 95% responded that they were somewhat or very interested in participating.

Discussion

Our diverse study population of CRC survivors allowed us to examine several sociodemographic characteristics, cancer-related factors, and indicators of health and well-being as correlates of non-adherence to a healthy lifestyle. One-half of the survivors were not adhering to a healthy lifestyle, as defined by two or more lifestyle risk factors. Adherence was lowest for fruit and vegetable intake (only 27% meeting recommendations) and highest for smoking (78% not smoking). The strongest correlates of poor adherence to a healthy lifestyle were indicators of poor mental and physical

Table 2 Sociodemographic and health characteristics of new Mexico colorectal cancer survivors by overall lifestyle quality

Characteristics	Everyone (%)	Number of unhealthy lifestyle factors			p[a]
		0 or 1 (Low risk) (%)	2 (Moderate risk) (%)	3 or 4 (High risk) (%)	
Demographic (*n*, %)					
Age					0.54
< 60	91 (32.2)	43 (30.1)	25 (30.9)	23 (39.0)	
60–66	94 (33.2)	47 (32.9)	26 (32.1)	21 (35.6)	
> 66	98 (34.6)	53 (37.1)	30 (37.0)	15 (25.4)	
Sex					0.10
Male	149 (52.7)	75 (52.5)	49 (60.5)	25 (42.4)	
Female	134 (47.4)	68 (47.6)	32 (39.5)	34 (57.6)	
Ethnicity					0.80
Hispanic	117 (41.3)	61 (42.7)	31 (38.3)	25 (42.4)	
Non-Hispanic	166 (58.7)	82 (57.3)	50 (61.7)	34 (57.6)	
Residence[b]					0.17
Rural	112 (39.6)	50 (35.0)	33 (40.7)	29 (49.2)	
Urban	171 (60.4)	93 (65.0)	48 (59.3)	30 (50.9)	
Education					0.85
≤ HS or GED	75 (26.6)	36 (25.2)	22 (27.5)	17 (28.8)	
Beyond HS	207 (73.4)	107 (74.8)	58 (72.5)	42 (71.2)	
Household income[c]					0.12
Low	92 (34.7)	41 (29.9)	25 (35.2)	26 (45.6)	
Moderate to high	173 (65.3)	96 (70.1)	46 (64.8)	31 (54.4)	
Living arrangement					0.69
Not alone	186 (66.2)	94 (65.7)	55 (69.6)	37 (62.7)	
Alone	95 (33.8)	49 (34.3)	24 (30.4)	22 (37.3)	
Employment status					0.08
Employed	110 (39.0)	58 (40.6)	24 (30.0)	28 (47.5)	
Retired	120 (42.6)	62 (43.4)	41 (51.3)	17 (28.8)	
Other	52 (18.4)	23 (16.1)	15 (18.8)	14 (23.7)	
Cancer-related factors (*n*, %)					
Stage					0.64
Early (I–II)	192 (67.8)	99 (69.2)	56 (69.1)	37 (62.7)	
Late (III–IV)	91 (32.2)	44 (30.8)	25 (30.9)	22 (37.3)	
Time since diagnosis					0.51
≤ 5 years	130 (45.9)	64 (44.8)	35 (43.2)	31 (52.5)	
> 5 years	153 (54.1)	79 (55.2)	46 (56.8)	28 (47.5)	
Worry about recurrence/another cancer					0.26
No	66 (23.5)	28 (19.9)	24 (29.6)	14 (23.7)	
Yes	215 (76.5)	113 (80.1)	57 (70.4)	45 (76.3)	
Greater concern with CRC symptoms					0.20
No	197 (70.4)	102 (71.8)	59 (74.7)	36 (61.0)	
Yes	83 (29.6)	40 (28.2)	20 (25.3)	23 (39.0)	
Health and QOL (*n*, %)					
Number of comorbidities					**0.01**
0–1	143 (50.5)	82 (57.3)	41 (50.6)	20 (33.9)	
≥ 2	140 (49.5)	61 (42.7)	40 (49.4)	39 (66.1)	
General health					**0.005**
Good, very good, or excellent	207 (73.9)	116 (81.7)	57 (70.4)	34 (59.7)	
Fair or poor	73 (26.1)	26 (18.3)	24 (29.6)	23 (40.4)	
Poor physical functioning[d]					**0.001**

Table 2 (continued)

Characteristics	Everyone (%)	Number of unhealthy lifestyle factors			p[a]
		0 or 1 (Low risk) (%)	2 (Moderate risk) (%)	3 or 4 (High risk) (%)	
No	174 (61.9)	102 (71.3)	46 (57.5)	26 (44.8)	
Yes	107 (38.1)	41 (28.7)	34 (42.5)	32 (55.2)	
Depressive symptoms[d]					**0.01**
No	189 (68.0)	100 (70.9)	59 (74.7)	30 (51.7)	
Yes	89 (32.0)	41 (29.1)	20 (25.3)	28 (48.3)	
Anxiety symptoms[d]					**0.01**
No	190 (68.4)	99 (69.7)	60 (76.9)	31 (53.5)	
Yes	88 (31.7)	43 (30.3)	18 (23.1)	27 (46.6)	
Fatigue[d]					**0.01**
No	197 (71.6)	108 (76.6)	57 (75.0)	32 (55.2)	
Yes	78 (28.4)	33 (23.4)	19 (25.0)	26 (44.8)	
Poor satisfaction with social roles and activities[d]					**0.008**
No	177 (63.0)	98 (69.0)	52 (65.0)	27 (45.8)	
Yes	104 (37.0)	44 (31.0)	28 (35.0)	32 (54.2)	
Pain interference[d]					0.76
No	154 (55.0)	81 (57.0)	43 (53.8)	30 (51.7)	
Yes	126 (45.0)	61 (43.0)	37 (46.3)	28 (48.3)	

[a]The false discovery rate was adjusted using the Benjamini–Hochberg procedure. Bolded *p*-values are significant based on a 5% false discovery rate

[b]Urban defined as RUCA codes 1.0–2.0; rural defined as RUCA codes 3.0–10.6

[c]Low income = 200% of federal poverty level in 2015

[d]Scale from PROMIS-29 Questionnaire; yes = t-score > 0.5 SD from population mean (worse score)

health and well-being. Notably, the strongest association was observed for poor physical functioning.

Previous studies examining lifestyle scores among CRC survivors have generally reported an association between better adherence to lifestyle recommendations and better health-related QOL [12, 27–29]. Using the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30), Schlesinger et al., reported strong associations with physical, role, and social functioning domains and the number of favorable lifestyle factors [29]. In a smaller study also using the EORTC QLQ-C30 ($n = 155$ CRC survivors), Breedveld–Peters reported higher adherence scores were significantly associated with better physical functioning and with less fatigue, but no association was found for role or social functioning [27]. Our results extend the research by demonstrating the strong association between non-adherence to a healthy lifestyle and hrQOL in an ethnically, socioeconomically, and geographically diverse sample of CRC survivors. Differences between studies may be due to the operationalization of lifestyle recommendations or QOL surveys. Nevertheless, there is accumulating evidence that adherence to a higher number of lifestyle recommendations is associated with better QOL, or vice versa. Longitudinal studies with large samples of CRC survivors are needed to determine how lifestyle behaviors, health, and QOL change over time.

A noteworthy finding in our study was that poor physical functioning was the strongest correlate of being in the high-risk category (greater number of unhealthy lifestyle factors), and the only independent correlate after adjustment for sociodemographic characteristics, cancer-related factors, and other indicators of physical, mental, and psychosocial health and well-being. This strong impact, in terms of the strength of the association, of physical functioning on adherence to lifestyle recommendations has also been identified in other studies [27–29]. Physical function is a critical component of health and well-being as it is a strong predictor of future disability, the ability to live independently, and premature mortality [46, 47]. Whether lifestyle factors preceded poor physical functioning or vice versa is immaterial. It is crucial that researchers keep baseline level of physical functioning in mind when designing interventions, especially the physical activity component for multiple health behavior change interventions.

While 77% of CRC survivors in this study had poor adherence to either physical activity or dietary recommendations, 71% and 78%, respectively, were interested in receiving information on exercise and eating a healthy diet,

Table 3 Age-adjusted odds ratios (95% confidence intervals) for correlates of poor adherence to a healthy lifestyle among New Mexico Colorectal Cancer Survivors

Characteristics	Number of unhealthy lifestyle factors[a]			
	0 or 1 (Low risk)	2 (Moderate risk)	3 or 4 (High risk)	*p* value[b]
Sociodemographic factors				
Age (years)	Reference	1.01 (0.97–1.05)	0.97 (0.93–1.00)	0.12
Females vs. males	Reference	0.73 (0.42–1.27)	1.39 (0.75–2.59)	0.18
Hispanic vs. non-Hispanic	Reference	0.84 (0.48–1.46)	0.95 (0.51–1.77)	0.82
Rural vs. urban[c]	Reference	1.27 (0.72–2.23)	1.98 (1.06–3.72)	0.10
≤HS vs. > HS education	Reference	1.13 (0.61–2.09)	1.21 (0.61–2.39)	0.85
Low household income[d]	Reference	1.28 (0.69–2.35)	1.88 (0.99–3.58)	0.15
Living alone vs. not alone	Reference	0.84 (0.43–1.64)	1.15 (0.56–2.35)	0.75
Cancer-related factors				
Late vs. early stage	Reference	1.00 (0.55–1.81)	1.37 (0.72–2.59)	0.60
< 5 vs. ≥ 5 years since dx	Reference	1.06 (0.59–1.90)	1.50 (0.80–2.82)	0.44
Worried about recurrence/another cancer	Reference	0.59 (0.32–1.12)	0.75 (0.36–1.57)	0.27
Greater concerns about cancer-related symptoms	Reference	0.87 (0.46–1.62)	1.59 (0.84–3.02)	0.23
Health and QOL				
Fair/poor general health	Reference	1.88 (0.99–3.57)	**2.96 (1.50–5.86)**	**0.006**
≥ 2 Comorbidities	Reference	1.29 (0.74–2.26)	**3.05 (1.58–5.87)**	**0.004**
Poor physical functioning[e]	Reference	**1.83 (1.03–3.25)**	**3.35 (1.76–6.39)**	**0.0009**
Depressive symptoms[e]	Reference	0.83 (0.44–1.54)	**2.31 (1.22–4.36)**	**0.01**
Anxiety symptoms[e]	Reference	0.69 (0.37–1.31)	**1.99 (1.06–3.74)**	**0.02**
Fatigue[e]	Reference	1.11 (0.58–2.13)	**2.52 (1.31–4.85)**	**0.02**
Poor ability to participate in social roles and activities[e]	Reference	1.19 (0.62–2.31)	**2.77 (1.35–5.67)**	**0.02**
Pain interference[e]	Reference	1.14 (0.66–1.99)	1.24 (0.67–2.30)	0.76

[a]Age-adjusted models using polytomous logistic regression

[b]The false discovery rate was adjusted using the Benjamini–Hochberg procedure. Bolded *p* values are significant based on a 5% false discovery rate

[c]Urban defined as RUCA codes 1.0–2.0; rural defined as RUCA codes 3.0–10.6

[d]Low income = 200% of federal poverty rate

[e]Scale from PROMIS-29; yes = t-score > 0.5 SD from population mean (worse score)

respectively. While the years more proximal to completion of cancer therapy have been considered a "window of opportunity" for initiating behavior change, the long-term CRC survivors were significantly more likely to express interest in receiving information on exercise. This could be a reflection of declining health and thus interest in ways to attenuate or reverse the decline. As expected, poor adherence to physical activity recommendations was strongly associated with poor physical functioning ($p < 0.0001$), which by itself may preclude patient engagement despite self-reported interest. Survivors with mild-to-moderate functional impairment may benefit from interventions focused on light-intensity physical activity [48, 49]. Survivors with more severe impairment would likely require more structured or intensive physical activity interventions [49].

While barriers to meeting recommendations for physical activity and fruit and vegetable consumption were not assessed in this study, interventions to improve nutrition and physical activity in this diverse population of CRC survivors will need to take a number of sociodemographic and health/QOL factors into consideration. Reducing the risk of recurrence, second malignancies, and the development or worsening of chronic conditions in this population through adoption of a healthy lifestyle will require efficient, cost-effective, and innovative intervention approaches.

Multiple health behavior change (MHBC) interventions, defined as targeting two or more health behaviors either simultaneously or sequentially [50], represent a more efficient and cost-effective approach to promote behavior change and achieve a higher impact on health. Theoretical constructs such as experiences, knowledge, self-efficacy, and self-regulatory skills acquired while changing one behavior can be carried over or transferred to other behaviors [51–53]. To date, the majority of MHBC interventions among cancer survivors have targeted diet and physical activity using a simultaneous approach [51]. However, this approach has

Table 4 Correlates of interest in receiving information on diet and physical activity, among colorectal cancer survivors not meeting guideline recommendations

Characteristic	Interest in receiving information on exercise[a]		*p* value
	Not interested (%)	Interested (%)	
Time since diagnosis			0.04
≤5 years	16 (64.0)	25 (40.3)	
>5 years	9 (36.0)	37 (59.7)	
Characteristic	Interest in receiving information on a healthy diet[b]		*p* value
	Not interested (%)	Interested (%)	
Anxiety symptoms[c]			0.03
No	36 (81.8)	99 (65.1)	
Yes	8 (18.2)	53 (34.9)	
Depressive symptoms[c]			0.007
No	37 (84.1)	97 (63.4)	
Yes	7 (15.9)	56 (36.6)	
Fatigue[c]			0.04
No	37 (86.0)	108 (71.1)	
Yes	6 (14.0)	44 (28.9)	

[a]Interest in receiving information on exercise, among CRC survivors not meeting physical activity recommendations (≥150 min per week of moderate-intensity activity or ≥75 min per week of vigorous-intensity activity)

[b]Interest in receiving information on eating a healthy diet, among CRC survivors not meeting the recommendation of 5 fruit and vegetable servings per day

[c]Scale from PROMIS-29; yes = t-score > 0.5 SD from population mean (worse score)

resulted in higher relapse and dropout rates in some trials and may be less feasible in some population subgroups [51, 54]. A sequential approach to MHBC may be more acceptable to and therefore more effective among cancer survivors with complex and multidimensional health and sociodemographic characteristics; however, more research utilizing this approach is needed.

Adaptive interventions may be another effective way to promote adoption of a healthy lifestyle in this population. The Sequential Multiple Assignment Randomized Trial (SMART) is a study design that accounts for heterogeneity of response to treatment [55–57]. Re-randomizing non-responders to alternative interventions at key decision points can better meet the specific and changing needs of the participants [56, 57] and potentially avoid or reduce relapse and dropout rates [58]. For example, non-responders may be re-randomized to an enhanced or alternative treatment, such as additional counseling or tools to facilitate behavior change.

Holistic approaches to health promotion programs may be particularly relevant for rural CRC survivors or CRC survivors with lower income, and worse physical and/or mental health and well-being. For example, a home-based mentored vegetable gardening intervention has shown great promise in increasing vegetable consumption, physical activity, physical functioning, and other aspects of QOL in cancer survivors [59, 60]. The gardens were established at the survivors' homes, thus increasing access to rural, older, and lower-income cancer survivors. Additionally, many gardening tasks are considered light-to-moderate-intensity activities, thus reducing the physical demands on individuals with lower baseline physical functioning. Other examples include mind–body interventions, such as Tai Chi or Qigong, which have been shown to reduce symptoms of fatigue, distress, and depression, and improve sleep quality and QOL [61–64]. The slow, flowing movements, specific postures, deep breathing techniques, and mediation can be performed either sitting or standing [65, 66], and thus are well suited for cancer survivors with moderate to severe comorbidities, including poor physical function.

Limitations of our study include the cross-sectional design and self-reported data of lifestyle behaviors. The survey was designed as a needs assessment and thus did not focus on the assessment of lifestyle behaviors. As such, the only area of diet assessed was fruit and vegetable servings, which reduced participant burden; however, guidelines for a healthy diet also include increased consumption of whole grains, and reduced consumption of refined grains, processed meat, and red meat [17, 18]. Only leisure-time physical activity was assessed. Household, occupational, and/or transportation related physical activity might have varied by sociodemographic or health-related factors. However, leisure-time physical activity is an important indicator and

is most associated with health benefits. Barriers to healthy eating and physical activity were not assessed; however, we were able to examine some common barriers (e.g., comorbidities, fatigue, poor physical functioning) as correlates of poor health behaviors. Despite these limitations, our study has a number of strengths. Our study sample included a very diverse sample of male and female CRC survivors (41% Hispanic ethnicity, 40% rural, 35% low income, and 49% with multiple comorbidities). Our questionnaire assessed a large number of issues that are important to survivorship, allowing us to examine a larger number of potential correlates of lifestyle risk factors.

In conclusion, since the number of (un)healthy lifestyle factors may have a synergistic effect on health outcomes, it is important to identify CRC survivors most in need of lifestyle improvement. Future lifestyle promotion programs should carefully consider indicators of poor physical and psychosocial health and well-being, especially poor physical functioning in the design, recruitment, and implementation of these programs. MHBC or adaptive interventions may provide an efficient and cost-effective strategy to facilitate the adoption of a healthy lifestyle among CRC survivors most in need.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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

Informed consent Informed consent was obtained from all individual participants included in the study.

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