Published in final edited form as:
Nutr Cancer. 2018 January ; 70(1): 51–60. doi:10.1080/01635581.2018.1397707.

Associations Between Dietary Patterns and Longitudinal Quality of Life Changes in Colorectal Cancer Patients: The ColoCare Study

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Supplemental data for this article can be accessed on the publisher's website.

Authors' Contributions

BG was involved in data acquisition, data analysis and interpretation. HBo was involved in the concept and design of nutritional data analysis and interpretation. RT gave statistical advice. JB, NH, DS, PSK, CAM and StS revised the manuscript and were involved in data acquisition and interpretation. HBr, JCC, MH, KS and PBJ revised the manuscript and were involved in data analysis and interpretation. MS and AU revised the manuscript and were involved in data interpretation and gave medical advice. AU and CMU are BG's supervisors, were involved in the concept and design, funding, data analysis and interpretation, and revised the manuscript.

Abstract

Quality of life (QoL) is an important clinical outcome in cancer patients. We investigated associations between dietary patterns and QoL changes in colorectal cancer (CRC) patients. The study included 192 CRC patients with available EORTC QLQ-C30 data before and 12 months post-surgery and food frequency questionnaire data at 12 months post-surgery. Principal component analysis was used to identify dietary patterns. Multivariate regression models assessed associations between dietary patterns and QoL changes over time. We identified four major dietary patterns: "Western" dietary pattern characterized by high consumption of potatoes, red and processed meat, poultry, and cakes, "fruit&vegetable" pattern: high intake of vegetables, fruits, vegetable oils, and soy products, "bread&butter" pattern: high intake of bread, butter and margarine, and "high-carb" pattern: high consumption of pasta, grains, nonalcoholic beverages, sauces and condiments. Patients following a "Western" diet had lower chances to improve in physical functioning (OR = 0.45 [0.21–0.99]), constipation (OR = 0.30 [0.13–0.72]) and diarrhea (OR: 0.44 [0.20–0.98]) over time. Patients following a "fruit&vegetable" diet showed improving diarrhea scores (OR: 2.52 [1.21–5.34]. A "Western" dietary pattern after surgery is inversely associated with QoL in CRC patients, whereas a diet rich in fruits and vegetables may be beneficial for patients' QoL over time.

Background

Colorectal cancer is the third leading cancer in men and second in women worldwide. In 2014, about 1.4 million new colorectal cancer cases occurred, with highest rates in economically developed countries (1). However, mortality rates have decreased throughout past decades as a result of earlier diagnosis, improved diagnostic tests and advances in cancer treatment (2,3). Yet, there is a strong need to satisfy and support patients' needs and expectations regarding their quality of life (QoL) after diagnosis or surgery (4). QoL is an important clinical outcome in cancer patients, in addition to recurrence and survival (2). It comprises a patient's individual judgment of life, including physiological, psychological, and social well-being. QoL can be related to tumor progression and therapy as well as to health behaviors, such as dietary habits (2,5). Over the past decades, interest in the impact of nutrition on cancer has increased and culminated in two milestone reports of the American Institute for Cancer Research (AICR) and the World Cancer Research Fund (WCRF) (6). They highlight the importance of associations between individual dietary intake and risk of i.e., colorectal cancer (6,7). Large epidemiological studies show that diets rich in fruits and vegetables and low in red and processed meat reduce colorectal cancer risk (8–10).

More recently, studies specifically revealed the influence of dietary patterns, rather than individual nutrients, on risk of recurrence or mortality in colorectal cancer patients (11–13). Most studies report on two general dietary patterns (a "Western" diet, characterized by high intake of meat, processed grains, potatoes, and desserts, and a "prudent" diet, characterized by high intake of fruits, vegetables, fish, whole grains, and olive oil) (11,12,14). A "Western" diet is generally associated with higher risks of adverse outcomes, whereas fruit-vegetable patterns and whole-food/"prudent" type diets appear to be beneficial for colorectal cancer patients (11,15). Prior studies showed that diet, nutritional status, and nutritional support may play an important role for avoiding complications and improving cancer patients' QoL (16,17). A healthy diet, reflecting high consumption of fruits, vegetables, and whole grain bread and a low intake of red and processed meat, was associated with better QoL in colorectal cancer patients (15,18). However, investigations of the effect of diet on clinical outcomes after diagnosis are rare. Recently, within a comprehensive literature review, van Blarigan et al. emphasized the need for research on associations between diet and QoL in colorectal cancer survivors (19).

To date, no study has performed an investigation of the associations between dietary patterns and changes of QoL in colorectal cancer patients after surgery. The aims of the present study were 1) to explore dietary behavior after surgery, 2) to elucidate QoL changes between time before surgery and 12 months post-surgery, and 3) to examine the associations between specific dietary patterns and selected longitudinal QoL changes in colorectal cancer patients.

Methods

Study Population

This study used data from ColoCare, a multicenter, international prospective cohort, initially developed at the Fred Hutchinson Cancer Research Center, Seattle, USA, and recruiting newly-diagnosed colorectal cancer patients prior to surgery, with the goal to investigate predictors of cancer recurrence, survival, treatment toxicities, and health-related QoL. Patients (eligibility: newly diagnosed, from the age of 18, stage 0/I–IV, German-speaking, and able to provide informed consent) from the ColoCare Heidelberg cohort were included in this study, recruited between October 2010 and February 2014 at the National Center for Tumor Diseases (NCT), Heidelberg, Germany (ClinicalTrials.gov Identifier: NCT02328677). Participants were staged according to the American Joint Committee on Cancer (AJCC) system based on histopathologic findings. Both colon carcinoma (ICD-10 C18) and rectal or rectosigmoidal cancer patients (ICD-10 C19/C20) were included. ColoCare has been approved by the ethics committee of the medical faculty at the University of Heidelberg. All study participants provided written informed consent. Patients with available food frequency questionnaire (FFQ) data at 12 months post-surgery, and baseline and 12 months follow-up QoL questionnaires were included. To reduce outliers, participants in the top and bottom 1% total energy intake range were excluded (20). Overall, 328 colorectal cancer patients were recruited. 34 patients deceased during the first 12 months after surgery, and 79 patients were lost to follow-up, refused the participation at the follow-up time point or did not fill out the 12 months questionnaire. Out of these 215 patients, 34 patients did not provide the FFQ. Thus, a total of 192 patients were included in the study.

Data Collection

Details on demographic, medical, and treatment factors were abstracted from patients' charts and records from the University Clinic of Heidelberg. Self-reported questionnaires were used to collect data on a set of multiple exposures among study participants as well as on a variety of potential risk factors including lifestyle characteristics and self-reported QoL-outcomes (e.g., the validated core questionnaire QLQ-C30, developed by the European Organization for Research and Treatment of Cancer (EORTC). The EORTC QLQ-C30 includes one global health/QoL status rating, five functional scales (cognitive, emotional, physical, role, and social), three symptom scales (fatigue, nausea and vomiting, and pain), and six items assessing symptoms (*i.e.*, appetite loss, constipation, and diarrhea) and financial impact of the disease (21). All scales were transformed into a range from zero to 100. Higher scores for the global health/QoL status and functional scales indicate better QoL. In contrast, higher symptom scores reflect a greater intensity of symptoms and thus worse QoL (22). On the basis of recently published evidence-based guidelines for interpretation of the EORTC QLQ-C30, longitudinal changes of QoL between baseline and 12 months post-surgery were categorized in deterioration, clinically trivial changes, and improvement (23). Ranges of clinically irrelevant differences of QoL are presented in Supplementary Table 1. The global health/QoL status and functional score has been defined as improved if the difference between two time points was above the irrelevance range, differences below this range were assigned to the deterioration category. For symptom scores the assignment of a change was performed *vice versa*. For the purpose of this study, eight scores and single items of the EORTC QLQ-C30 questionnaire were *a priori* selected (global health/QoL status, physical functioning, fatigue, pain, nausea and vomiting, loss of appetite, constipation, and diarrhea), reflecting the global health/QoL status as well as adverse side effects most frequently reported by cancer patients (24,25).

Dietary behavior was assessed using a validated semi-quantitative, self-administrated 148-item EPIC (European Prospective Investigation into Cancer and Nutrition) FFQ at 12 months post-surgery (26). The FFQ reflects the consumption frequency of a predefined portion size and eating frequency for all main food items during the past 12 months. Household measures were used to define portion sizes for each food item. Intake frequency was estimated by using a scale of categories ranging from “never”, “one time per month or less”, “two to three times per month”, “one to two times per week” to “three times per week or more”. By multiplying frequency per day and portion size, the average consumed amount was calculated and expressed as intake in gram per day. The 148 food items were grouped into 80 food classes by the German Institute of Human Nutrition Potsdam-Rehbruecke using the (EPIC)-Soft software and provided to the ColoCare study group (27). Numerous studies have specifically revealed the influence of dietary patterns, rather than individual foods or nutrients, on risk of recurrence or mortality in CRC patients (11–14). Thus, we assigned the 80 food classes to 25 food groups based on nutrient profiles or culinary usage according to the standardized classification of the well-established EPIC study (Supplementary Table 2) (28). These food groups were categorized according to their plant or animal origins and their degree of food processing (27,28). The food groups included four groups on vegetable intake (potatoes, fruiting/leafy/other vegetables, legumes, soy products), one group on dairy products, three groups on meat intake (red meat, processed meat, poultry), one group on fruit and fish, four groups on fat intake (butter, margarine, deep-frying fat and vegetable oil) and 12 other food groups.

Data Analysis

Principal component analysis was used to investigate factors explaining the maximum proportion of variance in the correlation matrix of the 25 derived food groups. An orthogonal transformation (varimax) was performed to rotate the correlation matrix in order to obtain a more efficient loading structure with greater interpretability (29). The number of factors to be retained in the model was determined by eigenvalues of the correlation matrix (greater than 1 for PCA), Scree plots, proportion of variance explained by the identified factors, and the natural interpretability of each factor (14, 30). Each individual was assigned a factor score for each identified pattern. Thus, individuals with high scores for a dietary pattern have a greater tendency to follow the pattern than individuals with a low score. Labeling of the factor was performed quantitatively using a cut-off of 0.35 of the factor loadings (Table 2). Additionally, each dietary pattern data was categorized into approximate appropriate tertiles. Fisher's exact tests were calculated to assess dietary habits within different groups: sex (female, male), BMI (<25, 25–30 and >30 kg/m^2) at baseline and 12 months post-surgery, tumor site (colon, rectal), tumor staging (0/I to IV), stoma at any time between time of surgery and 12 months follow-up (yes, no), adjuvant treatment (yes, no), and smoking (yes, no) at baseline and 12 months after. Arithmetic means for QoL scores were chosen as for some scores fewer than 50% of the patients reported any changes of QoL (e.g. nausea and vomiting, 79%), leading to a median of "0" (31). Wilcoxon tests were performed to evaluate age differences within tertiles of dietary pattern as well as longitudinal changes of QoL scores over time for all patients as well as by subgroups according to the four major dietary patterns. Finally, ordinal multivariate logistic regression models were performed to assess the associations between dietary patterns and QoL changes (categorized into deterioration, clinically trivial change, and improvement (Supplementary Table 3), with deterioration as the lowest one) (23). Based on the categorization of changes of QoL (categories are: 0 = deterioration, 1 = clinically trivial changes, and 2 = improvement), in the following analyses an OR >1 is interpreted as an "increased risk of improvement" and, thus, a better outcome or improvement of a specific QoL score. The final models were adjusted for *a priori* selected potential confounders (sex, age, tumor stage, tumor site, and stoma). In addition, we determined changes of smoking status (never smoker, stopped smoking, still smoker, started smoking) and calculated weight change between time before surgery and 12 months after, and considered a 10% weight loss as significant (32). Within a second model, we excluded those patients with at least 10% weight loss. In a third model, we included weight change as an additional covariate to the initial logistic regression model. As a fourth model, we included change of smoking status as an additional independent covariate.

In addition, we investigated parallel linear regression models using 12 months QoL measures as dependent variables adjusted for baseline QoL, using continuous QoL data. All tests were two-sided and p values below 0.05 were considered significant. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA).

Results

The study included n = 192 colorectal cancer patients with a mean age of 62.0 § 11.6 years 39% of patients were female and 61% male. Baseline and 12 month follow-up participants' characteristics are shown in Table 1.

Four major dietary patterns were identified: a "Western" type diet characterized by high consumption of potatoes, red and processed meat, poultry, and cakes, a "fruit&vegetable" dietary pattern characterized by high intake of vegetables, fruits, vegetable oils, and soy products, a "bread&butter" pattern characterized by high intake of bread, butter and margarine, and a "high-carb" pattern characterized by high consumption of pasta, grains, nonalcoholic beverages, and sauces and condiments (Table 2). A variance of 78% of the total dietary consumption was explained by these four patterns: The "Western" diet pattern explained 26.4%, "fruit&vegetable" explained 46.5%, "bread&butter" explained 17.5%, and the "high-carb" diet explained 12.6% of the variability.

During the 12 month period post-surgery, higher "Western" pattern scores were reported more frequently among men ($p < 0.01$). Moreover, higher "bread&butter" dietary pattern scores were detected in men, rectal cancer patients as well as in patients who had received a stoma ($p < 0.01$, $p = 0.01$ and $p < 0.01$, respectively). We observed higher intake of a "high-carb" diet in younger patients, in patients with a BMI > 30 kg/m2, as well as in patients who were active smokers at 12 months post-surgery ($p < 0.01$, $p = 0.04$ and $p = 0.02$, respectively). Further, we detected a close to significant finding for adherence to the "fruit&vegetable" dietary pattern among patients who received adjuvant chemotherapy ($p = 0.05$). We did not observe any associations between post-surgery dietary patterns and BMI, tumor stage, or smoking status at baseline (Table 3).

Overall, at 12 months post-surgery, global health/QoL status significantly improved ($p < 0.01$) compared to baseline, while the physical score deteriorated ($p < 0.01$). Loss of appetite and constipation severity decreased over time ($p = 0.03$ and $p = 0.03$, respectively) (Table 4). Patients characterized by high consumption of a "Western" diet reported less improvement in global health/QoL status and the constipation score ($p = 0.04$ and $p = 0.01$, respectively). Additionally, patients with higher "bread&butter" pattern scores reported less improvement in pain scores ($p = 0.04$).

After adjusting the final models for *a priori* selected confounders, individuals in the highest compared with the lowest tertile of the "Western" diet had lower chances to improve their physical functioning, constipation and diarrhea scores (OR: 0.45, CI: 0.21–0.99, $p = 0.04$; OR: 0.30, CI: 0.13–0.72, $p = 0.01$; OR: 0.44, CI: 0.20–0.98, $p = 0.04$) between surgery and 12 months after (Table 5). On the other hand, patients following a "fruit&vegetable" diet showed improving diarrhea scores (OR: 2.52, CI: 1.21–5.34, $p = 0.01$) (Table 6). Patients characterized by high consumption of a "bread&butter" diet reported significantly lower scores (= improvement) of loss of appetite (OR: 0.36, CI: 0.15–0.83, $p = 0.02$) (Table 7). In our additional models, by: (i) excluding patients with at least 10% weight loss between time before surgery and 12 months post-surgery, (ii) including weight change as an additional covariate to the initial model, and (iii) including change of smoking status 12 months post-surgery, all results were comparable to the initial model. In our independent analysis using 12 months QoL as the dependent variable and baseline QoL as additional covariate (QoL scores as continuous variables) results were generally consistent. We did not observe any associations between consumption of a "high-carb" diet and QoL changes (Supplementary Table 4).

Discussion

To the best of our knowledge, this is the first prospective cohort study investigating associations between dietary patterns and longitudinal changes of QoL in colorectal cancer patients between time before surgery and 12 months after. Our study provides valuable information about specific dietary patterns of colorectal cancer patients during the 12 month period post-surgery, and how these patterns are associated with the global health/QoL status, physical functioning, and clinical symptoms affecting colorectal cancer patients after surgery (2,33).

Four dietary patterns, “Western”, “fruit&vegetable”, “bread&butter” and “high-carb” predominantly characterized patients in this cohort within 12 months after surgery. Our findings are consistent with the “Western” and “prudent” diet patterns described previously in colorectal cancer patients (11,12). The “high-carb” pattern is in line with the “high carbohydrate” dietary pattern characterized by high factor loadings on convenience foods, pasta, and bread in endometrial cancer patients (34).

However, we observed for the first time a “bread&butter” pattern, which reflects high scores in bread, butter, and margarine. We did not find comparable dietary patterns in any other cancer cohort. This pattern may be more particular to the German population, as has been partly confirmed by the German National Nutrition Survey II, where the consumption of bread in Germany was the highest compared to other European countries (31). Consumption of the “bread&butter” dietary pattern was significantly higher in men, rectal patients as well as patients who received a stoma. It was associated with continued loss of appetite, perhaps reflecting lack of interest in cooking a more comprehensive meal, food aversion, or general diet disorder due to disease, surgery, or cancer treatment (35,36). Recently published results show that appetite loss in early follow-up was significantly associated with lower survival – a serious fact that requires a close-meshed monitoring of patients’ QoL and a more intensive medical and nutritional care to support patients to cope the disease (37).

In this study, patients characterized by high consumption of a “Western” diet reported less improvement in constipation and diarrhea scores over time. In contrast, high “fruit&vegetable” dietary pattern scores were associated with improved diarrhea scores. Dietary fiber, mainly found in fruits, vegetables, whole grains, and legumes, are known to be protective against constipation (38,39). Early case reports and studies showed a beneficial effect of dietary fiber on fecal incontinence and diarrhea (40,41). The “Western” dietary pattern does not reflect foods high in fiber, which may explain, at least in parts, a lack of improvement in constipation and diarrhea. However, adequate fiber intake might improve symptoms of constipation, while diarrhea symptoms might get worse with increasing fiber consumption (42). Thus, one needs to consider the possibility that it is not the dietary pattern that is responsible for the symptoms, but that the observed association may be also explained by reverse causation, that is, patients with diarrhea are less likely to eat fruits and vegetables (36).

Several studies show a positive impact of a healthy diet on QoL among colorectal, breast, and prostate cancer patients (15,18,43). A report addressing health-related behaviors in colorectal cancer patients described positive associations between a healthy diet (fruit and vegetable consumption) and the global health status as well as physical functioning (18). In the current study, patients characterized by high consumption of a “Western” diet were less likely to improve their global health/QoL status and physical functioning. This is the first study to our knowledge demonstrating that the consumption and preference of a specific dietary pattern may alter the course of the global health/QoL status and physical functioning.

Strengths of our study include its prospective design, with specific reference time point (time before surgery), follow-up and a standardized data collection. At each study time point, data on a comprehensive set of multiple exposures and QoL, as well as clinical data were collected. Prior studies already identified an important role of diet for avoiding complications and improving cancer patients' QoL (2,5,16,17). However, these studies were limited by a cross-sectional, non-prospective design or a small sample size (15,18,43–45).

Nevertheless, several limitations should be noted. Although our study is the largest prospective investigation, our results might suffer from limited statistical power. Since no multiple test correction was performed on our data, we cannot rule out that some of the results are false positives. Moreover, a possible selection bias can arise, because some patients died or did not complete follow-up questionnaires. It is possible that patients who experience more severe symptoms were overrepresented among those not completing follow-ups. Moreover, the relationship between diet and QoL is likely complex and bidirectional (46). As mentioned above, it is possible that diet was influenced by patients' QoL. Furthermore, although the FFQ is a validated and well established dietary assessment method, recall bias and underestimation or overestimation of food intake cannot be ruled out.

Conclusion

As one of the first prospective studies, we investigated the associations between dietary patterns and changes of QoL in colorectal cancer patients over time and underlined the importance of further investigations within this research area. Specific dietary patterns are associated with QoL changes after surgery. A "Western" dietary pattern is inversely associated with QoL, whereas a diet rich in fruits and vegetables seems to be beneficial for patients' QoL changes over time. However, more research is needed to understand the direction of these associations and to develop possible intervention strategies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors thank all ColoCare study participants and the entire ColoCare study team, especially Dr. Werner Diehl and the DACHS study team for data acquisition and documentation, Ellen Kohlsdorf and Ulrich Harttig for nutritional data calculation, and Judith Kammer, Susanne Jakob, and Torsten Kölsch for patient recruitment and follow-up.

Competing Interests and Funding

Biljana Gigic was funded by the Matthias Lackas Foundation, the ERA-NET on Translational Cancer Research (TRANSCAN) project 01KT1503, and the National Cancer Institute project R01CA189184. Dr. Cornelia M Ulrich and Dr. Jürgen Böhm were funded by the National Cancer Institute projects NIH R01 CA 189184 and NIH U01 CA 206110 and the Huntsman Cancer Foundation. Dr. Ulrich was further funded by NIH R01 CA207371. The Heidelberg ColoCare study was supported by the Matthias Lackas Foundation, the German Consortium of Translational Cancer Research (DKTK) and the Transcan-ERANET grant 01KT1503 (FOCUS consortium) and institutional funding from the German Cancer Research Center (DKFZ), Heidelberg, Germany to the Division of Preventive Oncology (Dr. Cornelia M. Ulrich, Dr. Hermann Brenner) at the National Center for Tumor Diseases (NCT), Heidelberg, Germany.

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Table 1

Baseline characteristics among ColoCare patients (n = 192).

Age (mean ± SD)	**62.0 ± 11.6**
Gender n (%)	
Female	74 (38.5)
Male	118 (61.5)
BMI (kg/m^2) at baseline, n (%)	
<25	70 (36.5)
25–30	84 (43.7)
> = 30	38 (19.8)
BMI (kg/m^2) at 12 months, n (%)	
<25	82 (42.7)
25–30	80 (41.7)
> = 30	30 (15.6)
Tumor site n (%)	
Colon	84 (43.7)
Rectum	108 (56.3)
Tumor stage n (%)	
0/I	52 (27.1)
II	67 (34.9)
III	47 (24.5)
IV	26 (13.5)
Stoma n (%)	
No	101 (52.6)
Yes	91 (47.4)
Adjuvant treatment n (%)	
No	110 (57.3)
Yes	79 (41.1)
Unknown	3 (1.6)
Smoking status at baseline n (%)	
Non smoker	158 (82.3)
Active smoker	33 (17.2)
Unknown	1 (0.5)
Smoking status at 12 months n (%)	
Non smoker	173 (90.1)
Active smoker	19 (9.9)

BMI = Body Mass Index, SD = standard deviation.

Table 2

Food group factor loadings for the “Western“, “fruit&vegetable“, “bread&butter” and “high-carb” dietary pattern, identified using PCA.

Food group	“Western“	“fruit&vegetable“	“bread&butter”	“high-carb”
Potatoes	**0.44**	0.09	−0.04	0.19
Vegetables	0.14	**0.68**	0.20	0.04
Legumes	0.30	0.33	−0.05	0.17
Fruits	−0.11	**0.45**	0.03	0.07
Dairy products	−0.04	0.01	0.04	0.29
Pasta, rice, and other grain	0.003	−0.02	−0.03	**0.37**
Bread	0.03	−0.04	**0.88**	0.10
Grains	−0.04	−0.02	−0.02	**0.37**
Red meat	**0.73**	−0.01	0.01	−0.29
Poultry	**0.44**	−0.03	−0.07	−0.12
Processed meat	**0.72**	−0.12	0.09	−0.11
Fish and shellfish	0.24	0.008	0.08	0.28
Eggs and egg products	0.34	0.03	0.06	0.27
Vegetable oil	0.02	**0.81**	−0.05	−0.11
Butter	0.13	0.002	**0.58**	0.33
Margarine	−0.02	−0.02	**0.49**	−0.20
Frying fat	0.27	0.06	0.17	−0.02
Sweets	0.33	−0.02	0.05	0.29
Cakes	**0.45**	−0.01	−0.05	0.08
Non-alcohol	−0.14	0.19	0.04	**0.36**
Wine	0.08	−0.03	0.02	−0.10
Other alcohol	0.17	−0.11	0.07	−0.02
Sauce and condiments	0.19	−0.08	0.05	**0.37**
Soups	0.06	0.17	−0.10	0.23
Soy	−0.10	**0.42**	−0.11	−0.02

Factor loadings greater than |0.35| are shown in bold.

PCA = Principal component analysis.

Table 3

Differences of adherence to specific dietary habits between different groups.

	Dietary patterns											
	"Western"			*"fruit&vegetable"*			*"bread&butter"*			*"high-carb"*		
	low	**medium**	**high**	**low**	**medium**	**high**	**low**	**medium**	**high**	**low**	**medium**	**high**
Age (mean ± SD)	61.8 ± 12.3	61.7 ± 11.5	62.6 ± 11.2	61.5 ± 11.2	62.4 ± 12.0	62.1 ± 11.9	63.6 ± 11.4	62.8 ± 11.0	59.6 ± 12.3	65.2± 10.3	61.9± 12.3	58.9± 11.5
		*p = 0.91**			*p = 0.90**			*p = 0.08**			***p<0.01*** *	
Sex n (%)												
Female	38 (59.4)	25 (39.1)	11 (17.2)	21 (28.4)	28 (43.7)	25 (39.1)	35 (54.7)	21 (32.8)	18 (28.1)	22 (34.4)	28 (43.7)	24 (37.5)
Male	26 (40.6)	39 (60.9)	53 (82.8)	43 (36.4)	36 (56.3)	39 (60.9)	29 (45.3)	43 (67.2)	46 (71.9)	42 (65.6)	36 (56.3)	40 (62.5)
		p < 0.01 **			*p = 0.47***			***p < 0.01*** **			*p = 0.58***	
BMI at baseline n (%)												
<25	23 (35.9)	28 (43.7)	19 (29.7)	23 (35.9)	22 (34.4)	25 (39.1)	25 (39.1)	25 (39.1)	20 (31.3)	19 (29.7)	26 (40.6)	25 (39.1)
25–30	26 (40.6)	28 (43.7)	30 (46.9)	31 (48.4)	25 (39.1)	28 (43.8)	29 (45.3)	27 (42.2)	28 (43.7)	29 (45.3)	31 (48.4)	24 (37.5)
>30	15 (23.4)	8 (12.5)	15 (23.4)	10 (15.6)	17 (26.5)	11 (17.2)	10 (15.6)	12 (18.7)	16 (25.0)	16 (25.0)	7 (11.0)	15 (23.4)
		*p = 0.32***			*p = 0.56***			*p = 0.69***			*p = 0.18***	
BMI at 12 months n (%)												
<25	26 (40.6)	31 (48.4)	25 (39.1)	27 (42.2)	28 (43.8)	27 (42.2)	27 (42.2)	30 (46.9)	25 (39.1)	24 (37.5)	27 (42.2)	31 (48.4)
25–30	27 (42.2)	26 (40.6)	27 (42.2)	29 (45.3)	21 (32.8)	30 (46.9)	29 (45.3)	25 (39.1)	26 (40.6)	27 (42.2)	33 (51.6)	20 (31.3)
>30	11 (17.2)	7 (10.9)	12 (18.7)	8 (12.5)	15 (23.4)	7 (10.9)	8 (12.5)	9 (14.1)	13 (20.3)	13 (20.3)	4 (6.2)	13 (20.3)
		*p = 0.70***			*p = 0.25***			*p = 0.72***			***p = 0.04*** **	
Tumor site n (%)												
Colon	36 (56.2)	25 (39.1)	23 (35.9)	27 (42.2)	30 (46.9)	27 (42.2)	35 (54.7)	30 (46.9)	19 (29.7)	34 (53.1)	28 (43.7)	22 (34.4)
Rectum	28 (43.8)	39 (60.9)	41 (64.1)	37 (57.8)	34 (53.1)	37 (57.8)	29 (45.3)	34 (53.1)	45 (70.3)	30 (46.9)	36 (56.3)	42 (65.6)
		*p = 0.05***			*p = 0.89***			***p = 0.01*** **			*p = 0.12***	
Tumor stage n (%)												
0/I	16 (25.0)	22 (34.4)	14 (21.9)	18 (28.1)	20 (31.2)	14 (21.9)	17 (26.6)	15 (23.4)	20 (31.3)	14 (21.9)	26 (40.6)	12 (18.7)
II	27 (42.2)	16 (25.0)	24 (37.5)	16 (25.0)	25 (39.1)	26 (40.6)	24 (37.5)	22 (34.4)	21 (32.8)	25 (39.1)	17 (26.6)	25 (39.1)
III	15 (23.4)	15 (23.4)	17 (26.6)	20 (31.3)	13 (20.3)	14 (21.9)	16 (25.0)	16 (25.0)	15 (23.4)	19 (29.7)	12 (18.7)	16 (25.0)
IV	6 (9.4)	11 (17.2)	9 (14.0)	10 (15.6)	6 (9.4)	10 (15.6)	7 (10.9)	11 (17.2)	8 (12.5)	6 (9.4)	9 (14.1)	11 (17.2)

	Dietary patterns											
	"Western"			***"fruit&vegetable"***			***"bread&butter"***			***"high-carb"***		
	low	**medium**	**high**	**low**	**medium**	**high**	**low**	**medium**	**high**	**low**	**medium**	**high**
		$p = 0.36^{**}$			*$p = 0.33^{**}$*			*$p = 0.93^{**}$*			*$p = 0.08^{**}$*	
Stoma at any time n (%)												
No	41 (64.1)	32 (50.0)	28 (43.7)	33 (51.6)	36 (56.3)	32 (50.0)	44 (68.7)	35 (54.7)	22 (34.4)	38 (59.4)	34 (53.1)	29 (45.3)
Yes	23 (35.9)	32 (50.0)	36 (56.3)	31 (48.4)	28 (43.7)	32 (50.0)	20 (31.3)	29 (45.3)	42 (65.6)	26 (40.6)	30 (46.9)	35 (54.7)
		$p = 0.06^{**}$			*$p = 0.81^{**}$*			**$p < 0.01^{**}$**			*$p = 0.31^{**}$*	
Adjuvant therapy n (%)												
No	40 (62.5)	34 (54.8)	36 (57.1)	29 (46.0)	39 (62.9)	42 (65.6)	38 (60.3)	32 (51.6)	40 (62.5)	37 (59.7)	35 (55.6)	38 (59.4)
Yes	24 (37.5)	28 (45.2)	27 (42.9)	34 (54.0)	23 (37.1)	22 (34.4)	25 (39.7)	30 (48.4)	24 (37.5)	25 (40.3)	28 (44.4)	26 (40.6)
		$p = 0.68^{**}$			*$p = 0.05^{**}$*			*$p = 0.44^{**}$*			*$p = 0.88^{**}$*	
Smoking at baseline n (%)												
No	56 (87.5)	50 (78.1)	52 (82.5)	56 (87.5)	49 (77.8)	53 (82.8)	54 (84.4)	55 (85.9)	49 (77.8)	55 (87.3)	55 (85.9)	48 (75.0)
yes	8 (12.5)	14 (21.9)	11 (17.5)	8 (12.5)	14 (22.2)	11 (17.2)	10 (15.6)	9 (14.1)	14 (22.2)	8 (12.7)	9 (14.1)	16 (25.0)
		$p = 0.37^{**}$			*$p = 0.35^{**}$*			*$p = 0.48^{**}$*			*0.16^{**}*	
Smoking at 12 months n (%)												
No	61 (95.3)	57 (89.1)	55 (85.9)	62 (96.9)	55 (85.9)	56 (87.5)	59 (92.2)	57 (89.1)	57 (89.1)	60 (93.7)	61 (95.3)	52 (81.2)
Yes	3 (4.7)	7 (10.9)	9 (14.1)	2 (3.1)	9 (14.1)	8 (12.5)	5 (7.8)	7 (10.9)	7 (10.9)	4 (6.3)	3 (4.7)	12 (18.8)
		$p = 0.18^{**}$			*$p = 0.08^{**}$*			*$p = 0.87^{**}$*			**$p = 0.02^{**}$**	

SD = standard deviation, BMI = Body Mass Index.

* p value Wilcoxon test.

** p value Fisher's exact test.

Table 4

QoL scores at baseline and 12 months post-surgery and longitudinal changes within the study population n = 192.

	baseline mean ± SD	12 months mean ± SD	diff mean ± SD	*p**
Global health status/QoL	57.6 ± 24.5	65.1 ± 19.9	7.2 ± 27.3	*<0.01*[a]
Functional aspects				
Physical functioning	83.6 ± 21.1	80.3 ± 19.2	−3.3 ± 21.8	*<0.01*[b]
Symptoms				
Fatigue	32.3 ± 28.8	34.1 ± 26.2	1.9 ± 28.3	*0.28*
Nausea and vomiting	4.5 ± 13.0	3.7 ± 11.2	−0.7 ± 15.7	*0.37*
Pain	23.4 ± 30.1	21.3 ± 27.7	−1.8 ± 34.5	*0.71*
Loss of appetite	15.4 ± 27.7	9.6 ± 21.8	−5.6 ± 28.5	*0.03*[a]
Constipation	15.7 ± 28.6	8.9 ± 19.5	−6.8 ± 32.8	*0.03*[a]
Diarrhea	21.8 ± 29.5	28.6 ± 35.1	7.0 ± 42.6	*0.10*

m = months, diff = difference of the means, SD = standard deviation.

[a]QoL score improvement over time.

[b]QoL score deterioration over time.

[*]p value Wilcoxon test.

Table 5

Longitudinal QoL changes between baseline and 12 months post-surgery within tertiles of the "Western" dietary pattern; Means and SD of QoL scores at baseline, 12 months post-surgery, and difference of means.

	"Western" diet pattern										
	low (mean ± SD)			medium (mean ± SD)			high (mean ± SD)				
	baseline	12 m	diff	baseline	12 m	diff	baseline	12 m	diff	p^a	p^b
Global health status/	57.9 ± 25.2	67.2 ± 18.2	8.6 ± 29.6	54.9 ± 25.1	67.2 ± 18.5	12.2 ± 24.8	60.0 ± 23.4	60.9 ± 22.5	0.9±26.6	*0.04*	*0.25*
Functional aspects											
Physical functioning	83.4 ± 21.1	82.4 ± 20.4	−1.0 ± 18.6	82.0 ± 23.0	80.9 ± 16.7	−1.0 ± 25.5	85.4 ± 19.3	77.6 ± 20.3	−7.8 ± 20.4	*0.10*	*0.04*
Symptoms											
Fatigue	30.4 ± 27.5	32.3 ± 27.0	2.3 ± 29.3	35.8 ± 29.1	37.3 ± 25.1	1.6 ± 30.5	30.6 ± 29.8	32.6 ± 26.6	2.0 ± 25.3	*0.95*	*0.31*
Nausea and vomiting	4.4 ± 14.3	4.5 ± 11.3	0.3 ± 16.3	5.7 ± 14.6	2.6 ± 9.9	−3.1 ± 17.0	3.4 ± 9.5	4.2 ± 12.2	0.8 ± 13.7	*0.18*	*0.66*
Pain	25.0 ± 31.4	18.3 ± 25.9	−5.8 ± 35.4	21.6 ± 28.1	19.3 ± 26.1	−2.3 ± 29.2	23.7 ± 31.0	26.3 ± 30.7	2.6 ± 38.2	*0.73*	*0.78*
Loss of appetite	15.6 ± 27.8	9.5 ± 21.9	−5.3 ± 31.2	16.7 ± 27.2	6.8 ± 17.0	−9.9 ± 29.5	14.1 ± 28.4	12.5 ± 25.5	−1.6 ± 24.1	*0.11*	*0.23*
Constipation	20.8 ± 32.8	7.9 ± 19.6	−13.2 ± 37.2	17.2 ± 29.1	7.3 ± 17.3	−9.9 ± 31.2	9.0 ± 21.8	11.5 ± 21.6	2.6 ± 27.6	*0.01*	*0.01*
Diarrhea	25.0 ± 30.9	27.5 ± 35.7	2.1 ± 47.1	17.2 ± 25.2	22.2 ± 32.2	5.8 ± 35.7	23.3 ± 32.0	35.9 ± 36.3	13.2 ± 44.2	*0.26*	*0.04*

m = months, diff = difference of the means, SD = standard deviation.

[a] p comparing differences between change of QoL from baseline to 12 months in "Western" diet tertiles, Wilcoxon test.

[b] p comparing changes in QoL (deterioration, clinically trivial changes, improvement), adjusted for sex, age, tumor stage, tumor site, stoma, in lowest vs. highest tertile of the "Western" dietary pattern.

Table 6

Longitudinal QoL changes between baseline and 12 months post-surgery within tertiles of the “fruit&vegetable” dietary pattern; Means and SD of QoL scores at baseline, 12 months post-surgery, and difference of means.

	“fruit&vegetable” diet pattern										
	low (mean ± SD)			medium (mean ± SD)			high (mean ± SD)				
	baseline	**12 m**	**diff**	**baseline**	**12 m**	**diff**	**baseline**	**12 m**	**diff**	***p***[a]	***p***[b]
Global health status/QoL	54.2 ± 24.9	64.3 ± 20.9	9.5 ± 30.7	58.1 ± 24.3	65.5 ± 18.1	7.4 ± 24.8	60.7 ± 24.3	65.5 ± 20.9	4.8 ± 26.4	*0.70*	*0.98*
Functional aspects											
Physical functioning	80.4 ± 24.7	80.3 ± 19.5	−0.1 ± 24.7	81.9 ± 20.2	80.1 ± 18.3	−1.8 ± 18.4	88.5 ± 17.3	80.5 ± 20.1	−8.0 ± 21.4	*0.21*	*0.24*
Symptoms											
Fatigue	35.8 ± 29.8	38.6 ± 26.2	3.2 ± 28.5	32.5 ± 30.9	33.5 ± 28.0	1.0 ± 27.0	28.6 ± 25.3	30.2 ± 24.0	1.6 ± 29.8	*0.78*	*0.64*
Nausea and vomiting	3.6 ± 9.1	3.2 ± 8.4	−0.3 ± 8.2	6.3 ± 18.2	2.1 ± 7.6	−4.2 ± 19.2	3.6 ± 9.6	6.0 ± 15.5	2.3 ± 17.0	*0.14*	*0.46*
Pain	21.6 ± 29.8	20.1 ± 25.1	−0.5 ± 31.5	28.1 ± 31.5	21.9 ± 28.0	−6.2 ± 36.9	20.6 ± 28.8	21.9 ± 30.3	1.3 ± 34.8	*0.41*	*0.25*
Loss of appetite	17.2 ± 27.2	11.6 ± 23.3	−4.8 ± 28.0	17.2 ± 30.3	8.9 ± 21.6	−8.3 ± 27.9	12.0 ± 25.5	8.3 ± 20.6	−3.6 ± 29.8	*0.64*	*0.43*
Constipation	15.6 ± 29.7	5.8 ± 16.4	−10.1 ± 34.7	17.2 ± 28.5	13.5 ± 22.8	−3.6± 32.0	14.3 ± 27.9	7.3 ± 18.3	−6.9 ± 31.8	*0.63*	*0.90*
Diarrhea	20.8 ± 27.5	32.3 ± 36.4	11.1 ± 44.0	17.7 ± 29.7	27.0 ± 33.3	10.1 ± 35.7	27.0 ± 31.0	26.6 ± 35.7	0.0 ± 47.1	*0.17*	*0.01*

m = months, diff = difference of the means, SD = standard deviation.

[a] p comparing differences in change from baseline to 12 months in “fruit&vegetable” diet tertiles, Wilcoxon test.

[b] p comparing changes in QoL (deterioration, clinically trivial changes, improvement), adjusted for sex, age, tumor stage, tumor site, stoma, in lowest vs. highest tertile of the “fruit&vegetable” dietary pattern.

Table 7

Longitudinal QoL changes between baseline and 12 months post-surgery within tertiles of the “bread&butter” dietary pattern; Means and SD of QoL scores at baseline, 12 months post-surgery, and difference of means.

	“bread&butter” diet pattern										
	low (mean ± SD)			medium (mean ± SD)			high (mean ± SD)				
	baseline	12 m	diff	baseline	12 m	diff	baseline	12 m	diff	p^a	p^b
Global health status/QoL	55.6 ± 23.9	66.3 ± 19.5	10.1 ± 27.5	60.0 ± 25.0	67.4 ± 18.9	7.4 ± 27.1	57.3 ± 24.9	61.6 ± 21.1	4.3 ± 27.4	*0.89*	*0.67*
Functional aspects											
Physical functioning	83.3 ± 19.5	81.3 ± 20.1	−2.1 ± 18.0	81.6 ± 23.3	81.3 ± 16.8	−0.3 ± 23.0	85.9 ± 20.6	78.4 ± 20.7	−7.5 ± 23.6	*0.24*	*0.70*
Symptoms											
Fatigue	33.3 ± 30.3	35.3 ± 24.3	2.3 ± 27.0	33.1 ± 27.8	30.9 ± 25.8	−2.2 ± 28.5	30.4 ± 28.6	36.1 ± 28.3	5.7 ± 29.2	*0.18*	*0.98*
Nausea and vomiting	4.9 ± 15.0	4.2 ± 10.4	−0.5 ± 16.7	4.4 ± 10.8	3.9 ± 11.8	−0.5 ± 14.2	4.2 ± 12.9	3.1 ± 11.5	−1.0 ± 16.5	*0.50*	*0.16*
Pain	26.0 ± 31.0	18.0 ± 27.0	−7.1 ± 35.3	24.0 ± 30.1	18.0 ± 25.1	−6.0 ± 33.4	20.3 ± 29.3	27.9 ± 30.1	7.6 ± 33.3	*0.04*	*0.12*
Loss of appetite	21.4 ± 32.2	9.5 ± 24.3	−11.1 ± 28.1	13.0 ± 24.2	8.3 ± 17.8	−4.7 ± 27.8	12.0 ± 25.5	10.9 ± 23.0	−1.0 ± 29.1	*0.05*	*0.02*
Constipation	16.7 ± 29.7	8.5 ± 18.9	−8.5 ± 34.4	13.0 ± 27.0	6.8 ± 15.9	−6.3 ± 29.0	17.5 ± 29.2	11.5 ± 23.2	−5.8 ± 35.2	*0.90*	*0.17*
Diarrhea	28.1 ± 34.2	31.7 ± 38.4	3.8 ± 48.3	16.1 ± 23.0	23.4 ± 31.8	7.3 ± 35.9	21.2 ± 29.5	30.7 ± 34.8	10.1 ± 43.4	*0.69*	*0.79*

m = months, diff = difference of the means, SD = standard deviation.

[a] p comparing differences in change from baseline to 12 months in “bread&butter” diet tertiles, Wilcoxon test.

[b] p comparing changes in QoL (deterioration, clinically trivial changes, improvement), adjusted for sex, age, tumor stage, tumor site, stoma, in lowest vs. highest tertile of the “bread&butter” dietary pattern.