Diet quality and its relationship with overweight and laboratory parameters in breast cancer patients undergoing treatment

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Abstract

Background Overweight is the common issue existed among breast cancer patients, leading to poor cancer prognosis and survival. However, previous studies have focused merely on single nutrients or food groups. This study aimed to determine whether diet quality was associated with overweight and laboratory parameters among breast cancer patients undergoing treatment. **Methods** A cross sectional study comprises of 163 patients was conducted from January to May 2017. Diet quality and level of physical activity of patients were ascertained using Healthy Eating Index (HEI)-2015 and International Physical Activity Questionnaire (IPAQ)-short form, respectively. Data were available on body mass index and biochemical data, including of serum albumin, serum hemoglobin and neutrophils count. Logistic regression was performed to identify the association between diet quality and overweight, serum albumin, serum hemoglobin and neutrophils count. **Results** The mean total HEI score (standard deviation) of the breast cancer patients was 63.86 (8.75). More than 80% of the subjects did not adhere to the dietary guidelines for whole grains, dairy, refined grains, ratio of poly- and mono-unsaturated fatty acids to saturated fatty acids components. In the multivariate model, those who perceived higher score of total HEI-2015 were less likely to experience overweight (Q4 vs Q1: OR=0.36; 95% CI=0.13, 0.99) while reported higher concentration of serum hemoglobin (Q4 vs Q1: OR=0.36; 95% CI=0.13, 0.98; Q3 vs Q1: OR=0.35; 95% CI=0.13, 0.92). Non-significant associations of diet quality were shown for serum albumin and neutrophils count. **Conclusions** A majority of breast cancer patients require dietary modification, especially for fatty acids, grains and dairy products. Diet quality may associate with overweight. A balanced diet that address the problem of overweight may help to maintain a good nutritional status and to improve cancer care in breast cancer patients during treatment. Future prospective studies are required to confirm this association.

Background

Cancer- and treatment-related factors have resulted in various undesirable health outcomes among the cancer patients. Unlike other cancers such as head and neck, gastrointestinal tract, liver and lung cancers, patients with breast cancer have lower risk of undernutrition^{1,2}. Weight gain is the common issue among breast cancer patients undergoing treatment³, which may have detrimental effect on survival as a result of inflammation^{4,5}. In addition, breast cancer patients often suffer from anemia and neutropenia⁶, leads to poor prognosis. While low serum hemoglobin is related to increased level of fatigue, reduced ability to perform daily tasks and impaired quality of life^{6,7}, an abnormally low neutrophils count predisposes cancer patients to bacterial infection, which could be life-threatening⁸. Such negative impact of altered blood readings on patients' prognosis might indirectly influence treatment compliance, in light of the close linkage between quality of life and treatment compliance⁹.

Physical activity and diet are established modifiable factor of body weight¹⁰ via principle of energy imbalance. A prospective study highlighted that breast cancer patients had low self-reported physical activity level especially during treatment¹¹, which could be in relation to the treatment-induced fatigue or

lymphedema. With regards to dietary assessment, diet quality measure provides a better understanding on the overall picture of diet consumed in accordance with dietary guidelines, rather than depend on single nutrients¹². This tool has been extensively used in epidemiological studies on predicting various health outcomes risks¹². In addition to the reduction in cancer risk¹³, healthier diet was found to associate with reduced inflammation¹⁴ and improved prognosis among breast cancer survivors^{15,16}. The health benefit of diet could be explained by the food synergy concept¹⁷, in which each of the nutrients acts simultaneously to yield an effective biological pathway. Conversely, Wu (2016) highlighted that insufficient protein intake could solely compromise the immune function¹⁸, which may forsake such notion that an evaluation of combined food is more informative in regards to a particular health issue. Nevertheless, study on diet quality may associate with overweight and altered biochemical parameters for breast cancer patients, at the critical phase of on-going treatment is relatively sparse.

As poor diet is commonly perceived to be linked with cancer development^{19,20}, cancer patients are likely to consume low fat, high fiber diet upon diagnosis^{21,22}. Nonetheless, few studies highlighted the reduced diet quality during treatment among breast cancer patients, which resulted from the poor adherence to dietary guidelines for the components of fruits and vegetables^{23,24}, grains, solid fats, alcohol and added sugars²³. This could be explained by the altered taste or increased eating pleasure for “heavy taste” food during treatment²⁵. Preference for spicy and salty food was found to associate with overweight in breast cancer patients, in light of its potential impact on increased overall appetite via oral sensory stimulation²⁵. Diet quality summarizes dietary habits and patterns of an individual in relation to factors such as compliance to dietary guidelines and nutrient adequacy²⁶ whereby the diet-disease relationship could be more detectable¹², which is imperative for the successful implementation of dietary strategies.

To the best of our knowledge, little is known about the linkage of diet quality with overweight and the common treatment-induced abnormal biochemical values. Hence this is the first study sought to determine the diet quality of breast cancer patients as well as its association with overweight and treatment-related side effects of hypoalbuminemia, low serum hemoglobin and low neutrophils count. Such information could assist dietitians to identify patients who need improvement in their dietary intake, thus integrating nutritional care into optimal quality cancer care.

Methods

Design

This was a cross sectional study.

Samples

This study was conducted among breast cancer patients at National Cancer Institute, a reference and research centre on cancer in Malaysia. National Cancer Institute received an estimated of 20 new breast cancer patients every month. According to the equation suggested by Green (1919) and considering the

number of predictors in this study was 11, the minimum sample size required for this study was 138. The recruitment response was overwhelming with a total of 227 breast cancer patients agreed to participate, and 179 eligible patients were enrolled using purposive sampling. The inclusion criteria were female, aged 29 – 71 years, receiving treatments (≥ 1 course) and able to provide written consent. Patients were excluded if they were under hospice care or have life expectancy of less than six months, pregnant or lactating, diagnosed with severe mental disorders or reduced ability to understand or communicate with others. In the final analysis, 16 patients were excluded due to incomplete data.

Data collection

The entire data collection process took five months (January – May 2017) and was carried out on patients' appointment day of treatment administration. Ethics approval of study protocol was obtained from the Ministry of Health's Research and Ethics Committee (MREC) and Ethic Committee for Research Involving Human Subject (JKEUPM), Universiti Putra Malaysia, with written informed consents obtained from all patients prior to study enrolment.

Measurements

Measurements of weight and height were taken to the nearest 0.1kg and 0.1cm, respectively, by using Detecto bariatric scale (6857DHR). Overweight was defined according to body mass index (BMI) cut off point of $\geq 25 \text{ kg/m}^2$ ²⁷.

Habitual dietary intake of patients over the past one month was assessed using a 165-items semi-quantitative Malaysians' Food Frequency Questionnaires (FFQ)²⁸. Dietary data were analysed using Nutritionist Pro version 4.0.0 (Axxya system, 2017) based on Malaysian food composition database as the primary source, and supplemented by Singaporean and USDA database (if there's lacking of food items in Malaysian database). Food consumption data was transformed into Healthy eating index-2015 (HEI-2015) scoring according to nine adequacy and four moderation components²⁹, to allow the determination of diet quality. Each food component was scored proportionately between the minimum and maximum standard as shown in Table 1. The summation of individual components yields a total HEI-2015 score, with higher score indicates better adherence to Dietary Guidelines for Americans 2015-2020²⁹. The total HEI-2015 score was divided into quartiles. In view of the lack of well-validated diet quality tool for Malaysians³⁰, the decision of utilizing HEI-2015 tool was made to assess patients' diet quality as it covers different food groups or subgroups which enables the result to be more discussable.

International Physical Activity Questionnaire (IPAQ)-short form was used to assess level of physical activity of patients over the past one week³¹. Total intensity level of physical activity (MET-min/week) was identified by taking consideration into frequency and duration of each activity. With higher reading of METs score indicates more intense physical activity, patients' physical activity level was further categorized into low, moderate or high accordingly.

Demographic information of patients such as age, marital status, educational level, employment status and monthly income were ascertained, besides medical characteristics which included time since diagnosis, cancer stage, treatment modalities and presence of comorbidities. Serum albumin, serum hemoglobin and neutrophils count after receiving at least one course of treatment were retrieved as secondary data. Hypoalbuminemia, low serum hemoglobin and low neutrophils count were categorised using the cut-off points of below 35 g/L, 12.00 g/dL and $2.00 \times 10^9/L$, respectively, which based on the laboratory references of NCI, Putrajaya.

Statistical analysis

All statistical analyses were performed using Statistical Software Package (IBM SPSS statistics version 22.0), with the statistical significance set at $p < 0.05$ (two-sided). Patients' characteristics were described as means $\pm$ standard deviations for continuous variables or counts with percentages for categorical variables. The differences in total mean HEI-2015 score were compared according to patients' characteristics, using analysis of variance (ANOVA) for age and month since diagnosis or chi-square test for categorical variables. Associations of HEI-2015 score with body weight status, levels of albumin, hemoglobin and neutrophils count were analyzed using binary logistic regression, controlled for demographic and medical characteristics (Model 1). Additional adjustments of moderate-to-vigorous physical activity and/or BMI were performed in Model 2, to examine any changes of observed association in the first model.

Results

Table 2 illustrated the patients' characteristics according to quartiles of diet quality scores. Patients with longer duration of diagnosis appeared to have poorer diet quality, in which post-hoc test revealed that quartile 1 had significantly longer duration of diagnosis than quartile 4. On the other hand, poorer diet quality was associated with the presence of comorbidity and overweight. None of the patients received concurrent treatment, while approximately half of them were on chemotherapy treatment alone. The overall mean (SD) of HEI score was 63.86 (8.75), with approximately 1 in 9 of the patients need dietary improvement, while only 4.3% subjects ($n=7$) adhered to dietary guidelines. In terms of components of diet quality (Figure 1), the median scores for adequacy components of Total Fruit, Whole Fruit, Total Vegetables, Greens and Beans, Total Protein Food, Seafood and Plant Proteins, as well as moderation components of Sodium, Added Sugars and Saturated Fats achieved the maximum scores of 100%. More than half of the subjects met the recommendation for above components. On the other hand, Whole Grains, Dairy, Fatty Acids and Refined Grains scored less than 25% of the maximum score, with only 20% of patients comply with the recommended intake of these four components.

As shown in Table 3, patients in quartile 4 were less likely to be overweight as compared to patients in quartile 1 after adjusting for demographic and medical characteristics [Model 1: OR=0.36; 95%CI=0.13,0.99]. An additional variable of moderate-to-vigorous physical activity did not substantially change this significant association. In model 1, higher diet quality was associated with lower odds of low

serum hemoglobin in quartile 3. The significance value was reduced after adjusting for moderate-to-vigorous physical activity and overweight [Model 2: OR=0.35; 95%CI=0.13, 0.92]. In quartile 4, the better diet quality was significantly showed with improved serum hemoglobin only after adjusting for behavioural factors [Model 2: OR=0.36; 95% CI=0.13, 0.98].

Discussion

This study investigated the associations of diet quality with overweight and treatment-related side effects among breast cancer patients undergoing treatment. In this study, the consumption of whole grains, dairy, fatty acids and refined grains were low. This finding was consistent with earlier studies^{23,24}. Avoidance and abstinence of certain foods are common among cancer patients, owing to belief that animal products are the causes of cancer development^{19,20} or treatment-related side effects that alter the taste perception²⁵. On the other hand, dairy products are not habitual intakes of Malaysian³², which may further attribute to the low consumption pattern of dairy products among the patients. Despite dairy products are good sources for protein, multivitamins and minerals which are essential for bodily functions, breast cancer patients may limit their dairy intake attributed to the concern about the safety of growth hormone usage in animal products²⁰. World Cancer Research Fund (WCRF) reviewed that the strength and direction of the effect of dairy products on cancer risk varied across the cancer sites^{33,34}. More studies are needed to confirm the impact of dairy products especially on breast cancer. Contrary to popular belief, the intake of whole grain products that commonly known as healthy food was low in this cohort of breast cancer patients. During treatment, cancer patients experience various side effects which could interfere with the ability of consuming a balanced diet^{25,35,36}, in spite of the high awareness of practising healthy eating. The compliance towards refined grain guideline could be deduced from the assessment of whole grains, where both of these components yield identical interpretation. As compared to whole grains, breast cancer patients prefer refined grains products with softer texture such as white rice, white bread or any food made with white flour. With regards to fatty acid component, the low score is originated from inadequate consumption of mono- and poly-unsaturated fatty acids. The individual component of saturated fat reflected that patients limited the food that are high in saturated fat, however, they did not adhere to the guidelines for unsaturated fatty acids. Although there is limited information regarding the fatty acid ratio, a consistent finding of the good compliance with saturated fatty acids intake was documented^{23,24}. Polyunsaturated fatty acids from marine sources are suggested to ameliorate treatment-related side effects and improve treatment efficacy via antineoplastic effect³⁷. In addition to saturated fatty acid, it is essential to assess the patients' intake of unsaturated fatty acids particularly during treatment. The biggest barrier to adherence to healthy fats recommendation could be high food prices³⁸, for instance, margarines with low saturated fat are more expensive than butter that high in saturated fat. A multi-faceted approach including implementing incentive-based policies to encourage the consumption of healthier fats, and via pricing schemes at supermarkets, convenience stores, and at markets to increase the accessibility of affordable healthy fats.

Current finding demonstrated that better diet quality has protective effect against overweight among breast cancer patients, as supported by Custódio et al. (2016)²⁴. Similar relationship between diet quality and obesity has been widely reported by public health studies^{39–41}. On the other hand, the finding of the relationship between diet quality and cancer risk or mortality was not consistent^{13,42}. As cancer is a multi-site disease with different treatment, the relationship of diet with cancer prognosis should be studied according to various cancer types, whereby the development of cancer site-specific diet quality tools is deemed necessary. As previous studies indicated the negative impact of obesity on quality of life⁴³ and survival^{4,5} of cancer patients, being overweight is not a desirable outcome for cancer patients who are usually considered to be malnourished. Adopting a healthy eating habit should be a bedrock of lifestyle strategy to achieve a normal weight range as well as to maintain an overall good health. Drenowatz et al. (2014) highlighted that high consumption of protein, sodium and empty calories were the contributors of overweight or obesity among healthy adults⁴⁰, indicating the necessity of achieving an adequate, balanced, moderate and varied diet. In view of the significant role of healthy eating in disease prognosis, the utilization of diet quality indices is relatively pragmatic for breast cancer patients. Despite the unhealthy dietary behaviour is strongly attributed to poor education in public health area¹⁰, current finding failed to show the significant relationship between education and diet quality. This could be because that the distribution of studied population according to education level was not widely covered, which may reduce the ability to determine the significant result.

Iron status of cancer patients should be closely monitored as the incidence of anemia could compromise greatly their quality of life⁴⁴. Current finding showed that higher quality diet was associated with reduced risk of low serum hemoglobin only after adjusting for physical activity and BMI (Model 2), suggests that diet quality might indirectly improve anemia by reducing excess body weight. It is noteworthy that the low serum hemoglobin could be owing to multiple nutrient deficiencies^{45,46} rather than a single nutrient. Vegetables and soy food that rich in iron or components enhancing iron absorption were found to associate positively with serum hemoglobin among middle-aged adults and elderly population^{46,47}. Vitamin C, in addition to iron, was found to be essential to prevent iron deficiency for obese patients who undergone bariatric surgery⁴⁸. Vegetables and soy groups are mainly included in Healthy Eating Index assessment, elucidating the necessity of consuming these components in line with the dietary guidelines. Likewise, Mardas et al. (2017) showed that a whole food rather than a single nutrient was related with chemotherapy-induced gastrointestinal symptoms⁴⁹. Iron rich food or dietary enhancers of iron absorption could be somehow beneficial to anemic cancer patients, despite the low hemoglobin level is generally attributable to cancer or treatment-related factors. With regards to the incidence of anemia, Thomson et al. (2011) recommended to keep body weight within a healthy range⁴⁵. Inadequate diet intake could predispose patients to iron deficiency while obese women are likely to experience interrupted iron absorption^{45,47}. In view of the potential inter-relationship between health indicators, investigation on the mediating effect of body mass index in respect to the association between diet quality and low serum hemoglobin are warranted. Despite the potential linkage of diet quality with serum hemoglobin, this

marker should be interpreted carefully as it may be affected by cancer prognosis related inflammation⁵⁰. More studies are warranted to delineate such relationship.

Breast cancer patients were more likely to adhere to dietary guidelines within the shorter duration of diagnosis. Despite earlier studies demonstrated a non-significant relationship of diagnosis time with diet quality in mixed cancer population or survivors^{15,26}, such relationship was implicitly supported by the study of Custódio et al. (2016)²⁴. Over the cancer treatment, a decline in diet quality was evident at the intermediate cycle of chemotherapy²⁴. In general, poor diet quality is attributed to lack of food varieties or an imbalanced diet. As a result of cancer treatment, nutrition impact symptoms, for instance, taste changes and nausea²⁵ could act as barriers to consuming a good quality diet. In making a decision for treatment plan, comorbidity is always a major issue for cancer patients in light of its potential dual burden on quality of life and survival⁵¹. In the present study, patients with comorbidities were shown to have poorer diet quality. Noting of the non-prospective study design, this finding does not preclude the notion of substantial impact of poor diet quality on the burden of multiple health outcomes. Despite demographic factors are considered as the risk factors of unhealthy diet in the causation pathway for non-communicable diseases¹⁰, none of the variables was associated significantly with diet quality in the present study. This could be explained by the varying extent of demographic influences on diet behaviour across the population groups.

The study is not without limitations. The limited sample size of this study may result in the issue of data sparsity, which may not be representative of the overall findings and warrant bigger sample size in the future studies. Despite Healthy Eating Index was found to be a well-established tool to predict obesity, it does not consider the key principle of balance, as referring that each food groups should be taken in right amount or proportion. In regard to this limitation, an underestimation of over-eating might be existed. Lack of nutrition information, particularly for saturated, mono- and polyunsaturated fatty acids, may undermine fatty acid in overall diet quality evaluation. However, additional food databases with higher availability of food items or nutrients were utilized in this study to minimize such bias. As the patient-reported outcomes rely on cancer types and treatment factors, these findings may not generalize to other cancer groups or trajectory phases. For instance, the study population excluded breast cancer patients in terminal stage with poor prognosis, in which the study finding could not be extrapolated to this population. The measurement periods of blood serum or body weight were inconsistent across phases of cancer treatment, which does not allow parallel comparison with diet history. This implies that the dietary assessment over the past one month is insufficient to reflect the overall dietary pattern during treatment and the assessment period should be extended considering the data reliability without compensating patients' burden. Besides, short assessment period of laboratory measures and body weight may also be insufficient to reflect the nutritional status of patients throughout the treatment, which may undermine the study finding.

Despite of the limitations mentioned above, the present study yields new insights into how a quality diet was linked to the clinical outcomes of patients with breast cancer, with the evaluation of the degree of

conformance in consumption of various food groups with dietary guidelines. Achieving a healthy weight range has been set as a primary goal to prevent nutrient deficiencies and to ensure an optimal health for cancer population⁵². The assessment of diet quality in breast cancer patients, particularly those receiving treatment, therefore, provides valuable information for the identification of patients’ nutritional status during this critical phase. Moreover, the association between diet quality and treatment-related side effects was performed using multivariate analysis, together with the adjustment of multiple confounders. This minimizes the bias that resulted from the factors that are out of study interest.

Conclusions

In conclusion, the overall diet quality of breast cancer patients is unsatisfactory with a majority of them need dietary improvement. A better diet quality was statistically associated with lower likelihood of overweight, however, the strength of such association was weak. On the other hand, non-significant associations were reported between diet quality and altered laboratory values. Findings from this study may serve as fundamental data regarding the impact of diet quality on overweight, which enable healthcare practitioners to implement effective strategies to improve patients’ nutritional status and cancer care. More investigations are deemed necessary to identify the exact mechanism of how is diet quality linked to overweight among breast cancer patients

List Of Abbreviations

MREC	Medical Research and Ethics Committee
IPAQ-SF	International Physical Activity Questionnaire-short form
FFQ	food frequencies questionnaires
HEI	Healthy eating index
BMI	Body mass index

Declarations

Ethics approval and consent to participate

Ethics approval was provided by Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia and Ethics Committee for Research Involving Human Subject Universiti Putra Malaysia. Patients’ written informed consents were obtained prior to study enrolment.

Consent for publication

The authors give the consent for this manuscript titled Nutrition Indicators, Physical Functions and Health-related quality of life to be published in BMC Nutrition.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no conflict of interest regarding the publication of this articles.

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Authors' contributions

All the authors planned and designed the study. The data were collected and computed by Krystal NLS. Chan YM and Zalilah MS were involved in data analysis and interpretation. Krystal NLS prepared the manuscript and this manuscript was editing or reviewed by Chan YM and Zalilah MS.

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Tables

Table 1: Standard scores of HEI-2015 components

HEI-2015 components	Maximum scores	Standard for maximum score	Standard for minimum score
Adequacy			
Total fruits	5	≥ 0.8 cup	No Fruits
Whole fruits	5	≥ 0.4 cup	No Whole Fruits
Total vegetables	5	≥ 1.1 cup	No Vegetables
Greens and beans	5	≥ 0.2 cup	No Greens and Beans
Whole grains	10	≥ 1.5 oz	No Whole Grains
Dairy	10	≥ 1.3 cup	No Dairy
Total Protein Food	5	≥ 2.5 oz	No Protein Foods
Seafood and Plant Proteins	5	≥ 0.8 cup	No Seafood and Protein food
Fatty Acids	10	$(\text{PUFAs} + \text{MUFAs})/\text{SFAs} \geq 2.5$	$(\text{PUFAs} + \text{MUFAs})/\text{SFAs} \leq 1.2$
Moderation			
Refined Grains	10	≤ 1.8 oz	≥ 4.3 oz
Sodium	10	≤ 1.1 g	≥ 2.0 g
Added sugars	10	$\leq 6.5\%$ of energy	$\geq 26\%$ of energy
Saturated fats	10	$\leq 8\%$ of energy	$\geq 16\%$ of energy

Table 2: Patients' characteristics by total HEI-2015 score

Parameters	Quartiles of HEI-2015 score				<i>p</i>
	1 (41 to <58.7)	2 (58.7 to <62.5)	3 (62.5 to <69.5)	4 (69.5 to 89)	
Number of patients	41	41	41	40	
Age (years), mean±SD	50.95±11.40	48.83±10.28	51.41±10.09	50.15±9.13	0.684
Educational level					0.567
Secondary level and below	25 (61.0)	27 (65.9)	21 (51.2)	25 (62.5)	
Higher education	16 (39.0)	14 (34.1)	20 (48.8)	15 (37.5)	
Month since diagnosis, mean±SD	11.01±6.69*	8.28±5.96	8.00±5.63	7.31±4.92*	0.027
Cancer stage					0.380
0/I/II	12 (29.3)	16 (39.0)	16 (39.0)	16 (40.0)	
III	19 (46.3)	15 (36.6)	18 (43.9)	10 (25.0)	
IV	10 (24.4)	10 (14.4)	7 (17.1)	14 (35.0)	
Chemotherapy (ongoing)					0.164
Yes	21 (51.2)	25 (61.0)	29 (70.7)	29 (72.5)	
No	20 (48.8)	16 (39.0)	12 (29.3)	11 (27.5)	
Radiotherapy (ongoing)					0.061
Yes	13 (31.7)	11 (26.8)	5 (12.2)	5 (12.5)	
No	28 (68.3)	30 (73.2)	36 (87.8)	35 (87.5)	
Hormonal therapy (ongoing)					0.316
Yes	13 (31.7)	7 (17.1)	7 (17.1)	8 (20.0)	
No	28 (68.3)	34 (82.9)	34 (82.9)	32 (80.0)	
Targeted therapy (ongoing)					0.904
Yes	7 (17.1)	5 (12.2)	6 (14.6)	7 (17.5)	
No	34 (82.9)	36 (87.8)	35 (85.4)	33 (82.5)	
Combined & single treatment modality					0.062†
Chemotherapy alone	19 (46.3)	24 (58.5)	27 (65.9)	24 (60.0)	
Radiotherapy alone	3 (7.3)	5 (12.2)	0 (0.0)	0 (0.0)	
Chemotherapy + Radiotherapy	19 (46.3)	12 (29.3)	14 (34.1)	16 (40.0)	
Presence of comorbidities					0.021
Yes	24 (58.5)	13 (31.7)	22 (53.7)	13 (32.5)	
No	17 (41.5)	28 (68.3)	19 (46.3)	27 (67.5)	
Meets moderate/vigorous PA					0.779
Yes	12 (29.3)	14 (34.1)	15 (36.6)	16 (40.0)	
No	29 (70.7)	27 (65.9)	26 (63.4)	24 (60.0)	
Overweight (≥25 kg/m ²)					0.021
Yes	28 (68.3)	19 (46.3)	23 (56.1)	14 (35.0)	
No	13 (31.7)	22 (53.7)	18 (43.9)	26 (65.0)	
Hypoalbuminemia					0.691
Yes	3 (7.3)	3 (7.3)	4 (9.8)	1 (9.1)	
No	38 (92.7)	38 (92.7)	37 (90.2)	39 (97.5)	
Low haemoglobin					0.186†
Yes	28 (68.3)	25 (62.5)	19 (46.3)	21 (52.5)	
No	13 (31.7)	15 (37.5)	22 (53.7)	19 (47.5)	
Low neutrophils count					0.700
Yes	3 (7.3)	5 (12.2)	6 (14.6)	6 (15.0)	

No	38 (92.7)	36 (87.8)	35 (85.4)	34 (85.0)	
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Data were presented as mean±SD or number (%)

Figures in bold indicate statistical significance based on ANOVA and chi-square test

*Post-hoc test revealed that Q1 had significantly higher score than Q4 (p=0.025)

†Statistical significance based on fisher's exact test

Table 3: Multivariate associations of total HEI-2015 score with overweight status and treatment-related side effects

	HEI-2015 score (ref: Quartile 1= 41 to <58.7)					
	2 (58.7 to <62.5)		3 (62.5 to <69.5)		4 (69.5 to 89)	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Overweight ^a						
Model 1	0.58 (0.22, 1.54)	0.270	0.70 (0.26, 1.83)	0.463	0.36 (0.13, 0.99)	0.047
Model 2	0.58 (0.22, 1.54)	0.270	0.70 (0.26, 1.83)	0.462	0.36 (0.13, 0.99)	0.047
Hypoalbuminemia ^b						
Model 1	0.94 (0.13, 6.74)	0.951	1.21 (0.20, 7.18)	0.832	0.17 (0.01, 2.15)	0.170
Model 2	0.87 (0.11, 6.73)	0.898	1.20 (0.19, 7.52)	0.847	0.13 (0.10, 1.96)	0.142
Low hemoglobin ^b						
Model 1	0.65 (0.24, 1.76)	0.398	0.37 (0.14, 0.95)	0.039	0.39 (0.14, 1.05)	0.062
Model 2	0.64 (0.24, 1.72)	0.374	0.35 (0.13, 0.92)	0.033	0.36 (0.13, 0.98)	0.046
Low neutrophils count ^b						
Model 1	1.47 (0.26, 8.32)	0.662	2.85 (0.55, 14.89)	0.214	2.36 (0.44, 12.63)	0.317
Model 2	1.15 (0.17, 7.65)	0.887	2.63 (0.45, 15.59)	0.286	1.88 (0.31, 11.34)	0.492

n=163 for each model fitted

^aModel 1: adjusted for age (continuous), higher education, time since diagnosis (continuous), cancer stage, hormonal therapy, comorbidity; Model 2: Model 1 + moderate-to-vigorous physical activity;

^b Model 1: adjusted for age (continuous), higher education, time since diagnosis (continuous), cancer stage, hormonal therapy, comorbidity; Model 2: Model 1 + moderate-to-vigorous physical activity + overweight

Figures

Figure 1: Radar graph of median components score in HEI-2015 and percentage of meeting dietary recommendations

Median scores of component were expressed in percentage (%)

Higher % indicate better conformance towards dietary guidelines

*Fatty Acids: ratio of poly- and mono-unsaturated fatty acids to saturated fatty acids

Figure 1

Radar graph of median components score in HEI-2015 and percentage of meeting dietary recommendations

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Tables.pdf](#)