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RELATIONSHIP BETWEEN MACRONUTRIENTS INTAKE AND CANCER STAGE WITH BODY MASS INDEX AMONG CANCER PATIENTS ON CHEMOTHERAPY

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ABSTRACT

Cancer is characterized by the uncontrolled growth and spread of abnormal cells, which can invade and destroy normal body tissue. Body mass index (BMI) is associated with cancer prognosis. Macronutrient intake affects BMI through lipogenesis, muscle formation, and lean body mass. Advanced cancer patients are at risk of malnutrition due to anorexia. The study aims to analyze the association between macronutrient intake and cancer stage with BMI of cancer patients undergoing chemotherapy. The study was used a cross-sectional design. Sampling was used a consecutive sampling technique with a sample size of 50 respondents. Macronutrient intake was collected through 3x24-hour non-consecutive food recalls. Cancer stage data were obtained from patient medical records. Body mass index (BMI) was calculated by dividing body weight (in kilograms) by square of height (in meters). Bivariate analysis used the Spearman-Rank correlation test. The results of the study showed that the median of energy and fat intakes were 1.051 kcal and 35.1 g. The mean of protein and fat intakes were 34.0±11.6 g and 152.4±47.5 g. The mean of energy, fat, and carbohydrate intake percentages were 58.5±17.5%, 70.5±28.6%, and 50.7±17.6%. The median of protein intake percentages was 48,7%. The percentage of energy, protein, and carbohydrate intake was considered a severe deficit, while the percentage of fat intake was considered a moderate deficit. There was association between energy intake and BMI (p-value=0.000; ρ=0.813), protein intake and BMI (p-value=0.000; ρ=0.723), fat intake and BMI (p-value=0.000; ρ=0.607), carbohydrate intake and BMI (p-value=0.000; ρ=0.812), and there was association between cancer stage and BMI (p-value=0.000; ρ=-0.606). It can be concluded that macronutrient intake and cancer stage was related to BMI in cancer patients.

Keywords**:** *body mass index; cancer; macronutrients*

ABSTRAK

Kanker merupakan penyakit yang terjadi karena beberapa sel tumbuh abnormal secara cepat dan bermetastasis ke bagian tubuh lainnya. Indeks massa tubuh (IMT) berhubungan dengan prognosis kanker. Asupan zat gizi makro memengaruhi IMT melalui lipogenesis, pembentukan otot, dan *lean body mass*. Pasien kanker stadium lanjut berisiko malnutrisi akibat anoreksia. Penelitian ini bertujuan untuk menganalisis hubungan asupan zat gizi makro dan stadium kanker dengan BMI pasien kanker kemoterapi di RSUD KHZ. Musthafa. Penelitian ini menggunakan desain *cross-sectional*. Pengambilan subjek menggunakan teknik *consecutive sampling* dengan jumlah sampel 50 responden. Asupan zat gizi makro diperoleh dengan 3x24 *hour non-consecutive food recall*. Data stadium kanker diperoleh melalui rekam medik pasien. IMT dihitung dengan membagi berat badan (dalam kilogram) dengan tinggi badan yang dipangkat dua (dalam meter). Analisis bivariat menggunakan uji korelasi Spearman-Rank. Hasil penelitian menunjukkan median asupan energi dan lemak adalah 1.051 kkal dan 35,1 g. Rerata asupan protein dan lemak adalah 34,0±11,6 g dan 152,4±47,5 g. Rerata persentase asupan energi, lemak, dan karbohidrat adalah 58,5±17,5%, 70,5±28,6%, dan 50,7±17,6%. Median persentase asupan protein adalah 48,7%. Persentase asupan energi, protein, dan karbohidrat tergolong defisit berat, sedangkan persentase asupan lemak tergolong defisit sedang. Terdapat hubungan antara asupan energi dengan IMT (*p-value*=0,000; *ρ*=0,813), asupan protein dengan IMT (*p-value*=0,000; *ρ*=0,723), asupan lemak dengan IMT (*p-value*=0,000; *ρ*=0,607), asupan karbohidrat dengan IMT (*p-value*=0,000; *ρ*=0,812), dan terdapat hubungan antara stadium kanker dengan IMT (*p-value*=0,000; *ρ*= -0,606). Dapat disimpulkan bahwa asupan zat gizi makro dan stadium kanker berhubungan dengan IMT pasien kanker.

Kata kunci: indeks massa tubuh; kanker; zat gizi makro

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PENDAHULUAN

Cancer is a disease that occurs when certain cells grow abnormally, rapidly and metastasize to other parts of the body (National Cancer Institute, 2021). The main cause of cancer is unknown, but several factors can potentially cause cancer, including modifiable factors such as smoking and being overweight or obese, and non-modifiable factors such as age and genetic mutations (American Cancer Society, 2024).

Cancer prevalence is generally increasing worldwide. According to data from the International Agency for Research on Cancer, the prevalence of cancer was 18.1 million in 2018, 19.1 million in 2020, and 19.9 million in 2022. Lung cancer is the most prevalent cancer (12.4%), followed by breast cancer (11.5%), and colorectal cancer (9.6%) (Globocan, 2022). The prevalence of cancer in Indonesia is 1.2 per 1,000 people, and in West Java it is 1.1 per 1,000 people (Kemenkes RI, 2023). This research was conducted in West Java because West Java is the most populous province in Indonesia, with 50,345 million people (BPS, 2024).

Body mass index (BMI) is associated with cancer prognosis. Cancer patients with a low BMI are at higher risk of overall survival in all cancer types compared to cancer patients with a normal BMI (Wen et al., 2024). Patients with a low BMI are at risk of experiencing poor treatment outcomes after radiotherapy (Lee and Choi, 2023). Patients with a low BMI are also less likely to receive adjuvant chemotherapy (Ren et al., 2015).

Macronutrient intake can influence BMI through various mechanisms, including lipogenesis, muscle formation, and lean body mass (Espinosa-salas and Gonzalez-arias, 2023). Lipogenesis occurs as a result of excess energy intake, particularly from carbohydrates, which are converted into triglycerides and stored in adipose tissue. If lipogenesis continues, it will cause fat accumulation in adipose tissue, resulting in changes in BMI that lead to obesity (Song et al., 2018).

Macronutrients also influence muscle formation. Adequate protein intake is essential for maintaining and building muscle mass, which can influence body composition and thus impact the BMI of cancer patients (Churchward-Venne et al., 2012). Furthermore, macronutrients contribute to lean body mass, which includes muscle, bone, water, and other tissues (Heymsfield et al., 2024). Adequate macronutrient intake plays a crucial role in maintaining lean body mass throughout life (Cena and Calder, 2020). Research conducted by Darmawan and Adriani showed a significant relationship between energy and macronutrient intake and BMI in cancer patients undergoing chemotherapy (Darmawan and Adriani, 2019).

Cancer stage can also affect BMI. Patients with stage II and III cancer tend to be underweight compared to patients with stage I cancer (Kroenke et al., 2016). Patients with advanced cancer are at greater risk of morbidity and mortality due to cancer cachexia. Patients with advanced cancer experience anorexia, which is influenced by metabolic and endocrinological factors, tumor anatomy, and cancer treatment (Yeom and Yu, 2022).

KHZ. Musthafa Regional Hospital is the only hospital in the East Priangan region that provides chemotherapy services for cancer patients. The number of cancer patients at KHZ. Musthafa Regional Hospital in 2024 reached 1.448 people with the number of patient visits undergoing chemotherapy as many as 639 people. This indicates that the hospital actively treats a significant number of cancer patients. Based on these data, the purpose of this study was to analyze the relationship between macronutrient intake and cancer stage with BMI of cancer patients undergoing chemotherapy at KHZ. Musthafa Regional Hospital.

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METHODS

The study was a quantitative study using a cross-sectional design. The population in the study refers to the number of chemotherapy cancer patients aged 25-54 years at KHZ.Musthafa Regional General Hospital in August-December 2024, with a total 131 people. The sample size in the study was calculated using the Lemeshow formula with a sample size of 50 respondents. Sampling in the study used a consecutive sampling technique. The sample inclusion criteria were aged 25-54 years, conscious and able to communicate, able to stand upright for anthropometric measurements, and not having complications or comorbidities such as kidney, heart, liver, tuberculosis, HIV, and diabetes mellitus. The sample exclusion criteria were patients receiving total parenteral nutrition and enteral nutrition with tube feeding.

Macronutrient intake data including energy, protein, fat and carbohydrates were collected through 3x24-hour non-consecutive food recalls consisting of two week-day and one week-end. A food photo book was used to facilitate respondents and researchers in estimating the size and weight of food consumed by respondents. The book was compiled by the Research and Development Agency of the Ministry of Health of the Republic of Indonesia in 2014. The food recall results were processed using the Nutrisurvey application. Cancer stage data were obtained from the medical records of cancer patients.

Body Mass Index (BMI) is calculated by dividing body weight (in kilograms) by height squared (in meters). Weight was measured using an Omron HN289 digital scale with an accuracy of 0.1 kg and a maximum capacity of 150 kg. Height was measured using a Metrisis stadiometer with an accuracy of 0.1 cm and a maximum capacity of 205 cm. All data were analyzed using a ratio scale. Data was analyzed using SPSS. The Kolmogorov-Smirnov normality test showed a normal distribution for protein and carbohydrate intake, while the energy and fat intake, cancer stage and BMI were not normally distributed. Univariate analysis for protein and carbohydrate intake used the mean and standard deviation. Univariate analysis for energy, fat, cancer stage and BMI used the median, minimum, and maximum values. Bivariate analysis used the Spearman-Rank correlation test. The study has received ethical approval from the Dian Nuswantoro University Research Ethics Committee with number : 002025/Universitas Dian Nuswantoro/2025.

HASIL DAN PEMBAHASAN

Univariate test results showed that the median energy intake was 1.051 kcal/day. Based on the European Society for Clinical Nutrition and Metabolism (ESPEN) practical guideline, clinical nutrition in cancer, total energy expenditure for cancer patients is estimated to be similar to that of healthy subjects, namely 25–30 kcal/kg/day (Muscaritoli et al., 2021). The injury factor uses 1.0–1.3 and activity factors for patients confined to bed are 1.2 (Nelms et al., 2012) so that it is known that the median energy requirement is 1.786.9 kcal. The average energy intake percentage is 58.5±17.5%. The recommendation of Widyakarya Nasional Pangan dan Gizi (WNPG) 2012, the level of macronutrient adequacy is divided into 5 categories including severe deficit (<70% of the required figure), moderate deficit (70-79% of the required figure), mild deficit (80-89% of the required figure), normal (90-119% of the required intake) and above the required intake (≥120% of the required intake) (Kartono et al., 2012). Therefore, it can be concluded that the average percentage of energy intake was considered a severe deficit. The description of nutrient intake among study subjects was shown in Table 1.

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Table 1. Univariate analysis nutrition intake and characteristic of study subjects

Variable	Median	Mean±SD*
Macronutrients intake		
Energy intake (kcal)	1.051	
Protein intake (g)		34.0±11.6
Fat intake (g)	35.1	
Carbohydrate intake (g)		152.4±47.5
Macronutrients requirements		
Energy requirements (kcal)	1.786	
Protein requirements (g)	59,6	
Fat requirements (g)	49,6	
Carbohydrate requirements (g)	275,4	
Macronutrients intake percentages		
Energy intake percentages (%)		58,5±17,5
Protein intake percentages (%)	48,7	
Fat intake percentages (%)		70,5±28,6
Carbohydrate intake percentages (%)		50,7±17,6
Cancer Stage	3	
Body Mass Index (BMI) (kg/m^2)	18,7	

*SD: standard deviation

The average protein intake was 34.03±11.62 grams/day. Based on ESPEN practical guideline, clinical nutrition in cancer, the recommended protein intake is >1 g/kg/day and, if possible, up to 1.5 g/kg/day (Muscaritoli et al., 2021). In calculating protein requirements, we used 1.2 g/kg/day, resulting in a median protein requirement of 59.6 g and a median protein intake of 48.7%, which is considered a severe deficit. The median fat intake was 35.17 grams/day. Fat requirements were calculated using a 25% proportion of energy requirements, resulting in a median fat requirement of 49.6 g. The average percentage of fat intake was 70.5±28.6%, categorizing it as a moderate deficit.

The average carbohydrate intake was 152.41±47.57 grams/day. The calculation of carbohydrate requirements showed a median of 275.4 g, with an average percentage of carbohydrate intake was 50.7±17.6%, categorizing it as a severe deficit. One factor contributing to low macronutrient intake in cancer patients is loss of appetite. Loss of appetite is common in advanced cancer patients and negatively impacts their quality of life (Helgesen et al., 2024). Loss of appetite can be caused by changes in taste and smell, as well as changes in motility in the upper and lower gastrointestinal tract, leading to vomiting, early satiety and constipation (Fearon et al., 2011).

The median cancer stage was 3. Stage 3 (III) cancer is a locally advanced cancer. Referring to the Tumour, Nodes, and Metastasis (TNM) classification, stage III is T1-T4, N2-N3, M0. "T" indicates tumor size and invasion into surrounding tissue. T1-T4 is used to identify the size and extent of the tumor, with progressive enlargement and invasion from T1 to T4. "N" indicates tumor involvement in regional lymph nodes, with increasingly distal spread from N1 to N3. "M" can identify the presence of distant metastases from the primary tumor. M0 indicates that there are no distant metastases (Rosen and Sapra, 2025).

The median BMI was 18.7 kg/m². The normal BMI range for Asian adults is 18.5–22.9 kg/m² (WHO, 2000), so the median BMI is considered normal. BMI is associated with the prognosis of cancer patients. Underweight cancer patients have a greater risk of

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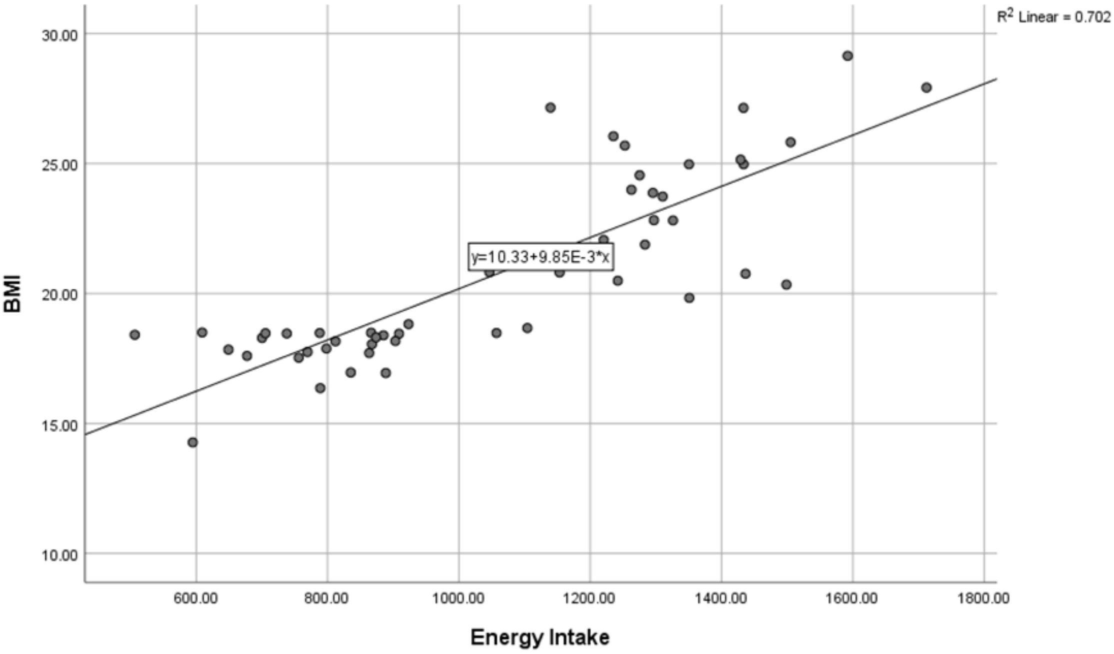
overall survival compared to normal-weight cancer patients in all cancers (including breast, gastric, and lung cancer) (Wen et al., 2024).



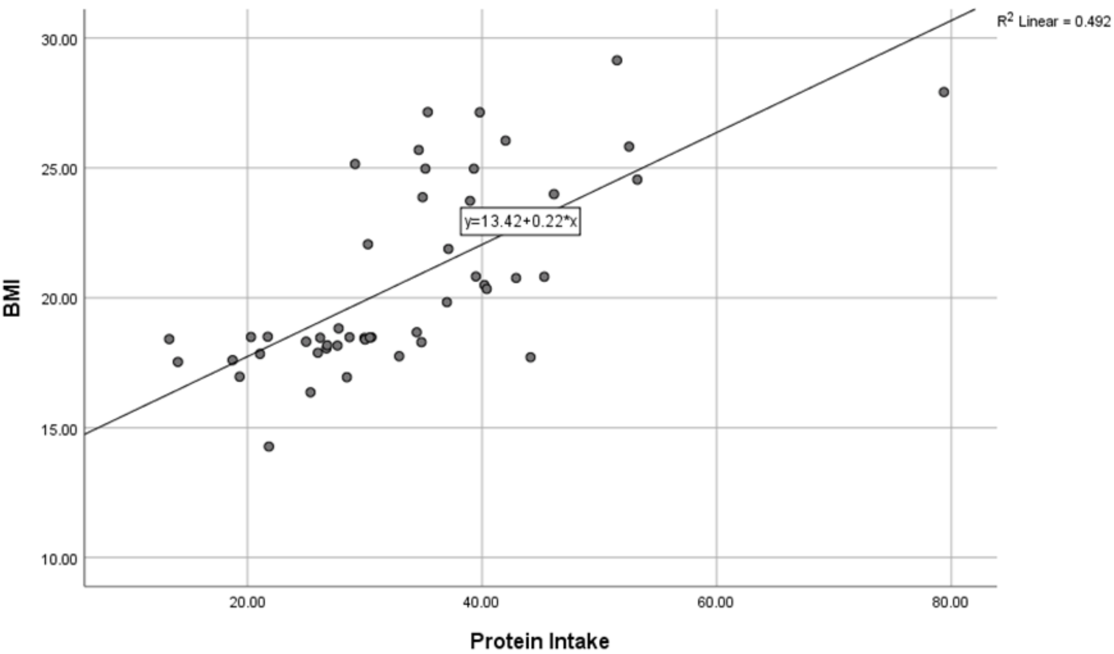
p-value=0,000 *ρ*=0,813

Figure 1. Scatter plot graph of the relationship between energy intake and BMI

The Spearman-rank test analysis resulted p-value of 0.000 (<0.05) that indicating a significant relationship between energy intake and BMI. The correlation coefficient value of 0.813 indicates a very strong level of relationship strength with a positive value indicating that the higher the energy intake, the higher the patient's BMI. Based on the scatter plot graph (Figure 1), it is known that the data distribution forms a straight prediction line from the bottom left to the top right, indicating that the higher the energy intake, the higher the patient's BMI.

Optimal energy intake is needed to maintain muscle mass by stimulating protein synthesis and suppressing protein breakdown (Prado et al., 2020). Cancer patients are at risk of malnutrition due to increased energy and protein requirements due to catabolic and physiological effects, inadequate food intake, and reduced physical activity (Arends et al., 2017). Patients must meet their energy needs to maintain a stable nutritional status (Muscaritoli et al., 2021). When the body lacks of energy, for example in starvation conditions, the body will undergo gluconeogenesis to produce glucose as the body's central energy source (Nakrani et al., 2020). Gluconeogenesis is a process that allows the body to form glucose from non-hexose precursors, especially glycerol, lactate, pyruvate, propionate, and glucogenic amino acids (Melkonian et al., 2022). Glycerol is produced through lipolysis (Edwards and Mohiuddin, 2020), so the higher the rate of gluconeogenesis, the higher the lipolysis, which can reduce BMI.

Based on the Spearman-rank test analysis, a p-value of 0.000 (<0.05) was obtained, indicating a significant relationship between protein intake and BMI. The correlation coefficient value of 0.723 indicates a strong relationship with a positive value, indicating that the higher the protein intake, the higher the patient's BMI. Based on the scatter plot graph (Figure 2), it is known that the data distribution forms a straight prediction line from the bottom left to the top right, indicating that the higher the protein intake, the higher the patient's BMI.



p-value=0,000 ρ=0,723

Figure 2. Scatter plot graph of the relationship between protein intake and BMI

Adequate protein intake is a key factor in maintaining or increasing muscle mass. Increasing skeletal muscle mass requires a balance between net muscle protein and nutrients, which act as primary anabolic stimuli. Amino acids stimulate protein synthesis and provide the building blocks for anabolism (Prado et al., 2020). High protein intake (>1.5 g/kg/day) is associated with better muscle mass maintenance and improved clinical outcomes in cancer patients, particularly critically ill patients (Toloi et al., 2025).

Protein is a macronutrient that plays a crucial role in the immune system. Amino acids are involved in the synthesis of immune proteins, including cytokines and antibodies that mediate immune responses (Li et al., 2007). Disruption of the regulation of amino acid consumption in immune cells leads to impaired antitumor immunity. The concentration of free amino acids, membrane-bound transporters, key metabolic enzymes, and sensors such as mTOR and GCN2 play a crucial role in controlling immune cell differentiation and function (Yang et al., 2023).

Dietary protein will be metabolized into amino acids, one of which is leucine, which acts as a signal to activate Muscle Protein Synthesis (MPS) through the mTOR pathway, which is responsible for regulating the translation of mRNA into new muscle protein (Churchward-Venne et al., 2012). The higher the protein intake, the higher the MPS, so that the body is able to form and maintain muscle tissue, which ultimately influences the increase in lean body mass and contributes to the increase in the patient's BMI (Antoun and Raynard, 2018).

Meanwhile, if protein intake is inadequate in cancer patients experiencing hypercatabolism, the body will undergo excessive Muscle Protein Breakdown (MPB). Prolonged MPB causes cachexia, a condition where muscle mass is lost in cancer patients. The loss of muscle mass impacts the patient's body composition and BMI, as well as reducing the patient's overall quality of life (Hanna et al., 2022). Muscle Protein Breakdown (MPB) occurs through various protein degradation pathways. Four main pathways play a role in the protein degradation process including the lysosomal, caspase, calcium-dependent and ATP-ubiquitin-dependent pathways. These four pathways are

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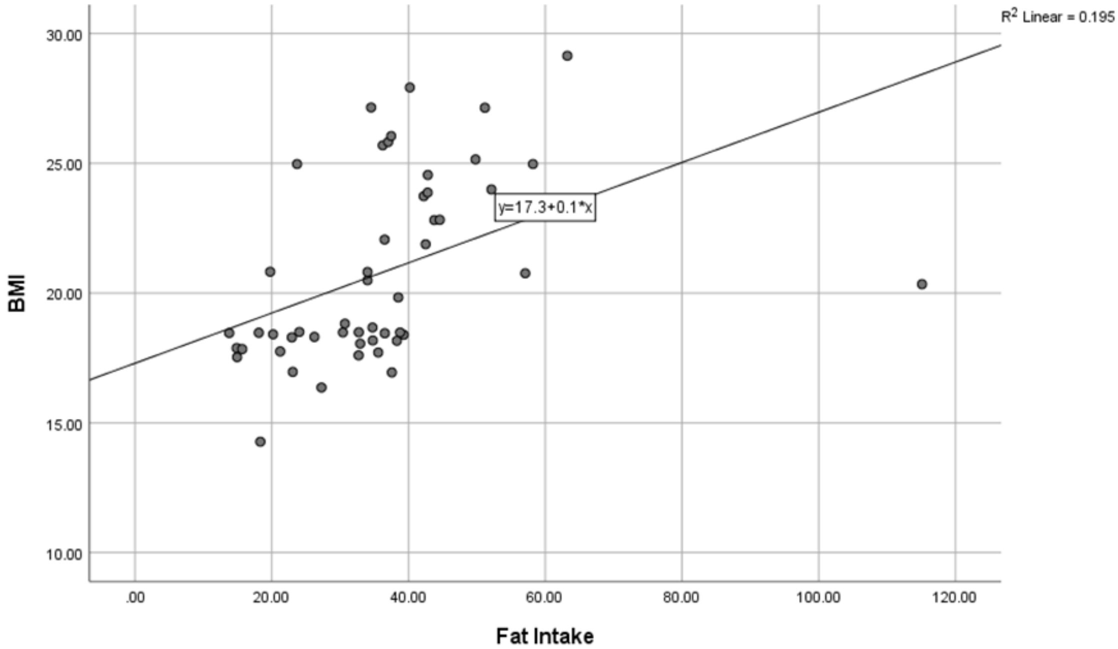
thought to be involved in the mechanism of muscle mass loss in cancer cachexia, but the ATP-ubiquitin pathway plays the most dominant role. In this pathway, the protein to be destroyed binds to the ubiquitin protein, which is then destroyed within the proteasome complex, requiring at least 6 ATP. Activation of the pathway is triggered by pro-inflammatory cytokines, which accelerate skeletal muscle breakdown (Krawczyk et al., 2014).



p-value=0,000 *ρ*=0,607

Figure 3. Scatter plot graph of the relationship between fat intake and BMI

Based on the Spearman-rank test analysis, a p-value of 0.000 (<0.05) was obtained, indicating a significant relationship between fat intake and BMI. The correlation coefficient value of 0.607 indicates a strong level of relationship strength with a positive value indicating that the higher the fat intake, the higher the patient's BMI. Based on the scatter plot graph (Figure 3), it is known that the data distribution forms a straight prediction line from the bottom left to the top right, indicating that the higher the fat intake, the higher the patient's BMI.

In this study, we used total fat intake and did not differentiate between saturated and unsaturated fat intake and BMI. However, Yiannakou et al. (2023) shows that higher saturated fat intake is associated with lower abdominal adiposity in both men and women, while higher unsaturated fat intake is associated with lower adiposity in women. Studies in mice have shown that a high-fat diet is associated with increased adiposity and body weight (Poret et al., 2018).

Based on the Spearman-rank test analysis, a p-value of 0.000 (<0.05) was obtained, indicating a significant relationship between carbohydrate intake and BMI. The correlation coefficient value of 0.812 indicates a very strong relationship with a positive value, indicating that the higher the carbohydrate intake, the higher the patient's BMI. Based on the scatter plot graph (Figure 4), it is known that the data distribution forms a straight prediction line from the bottom left to the top right, indicating that the higher the carbohydrate intake, the higher the patient's BMI.

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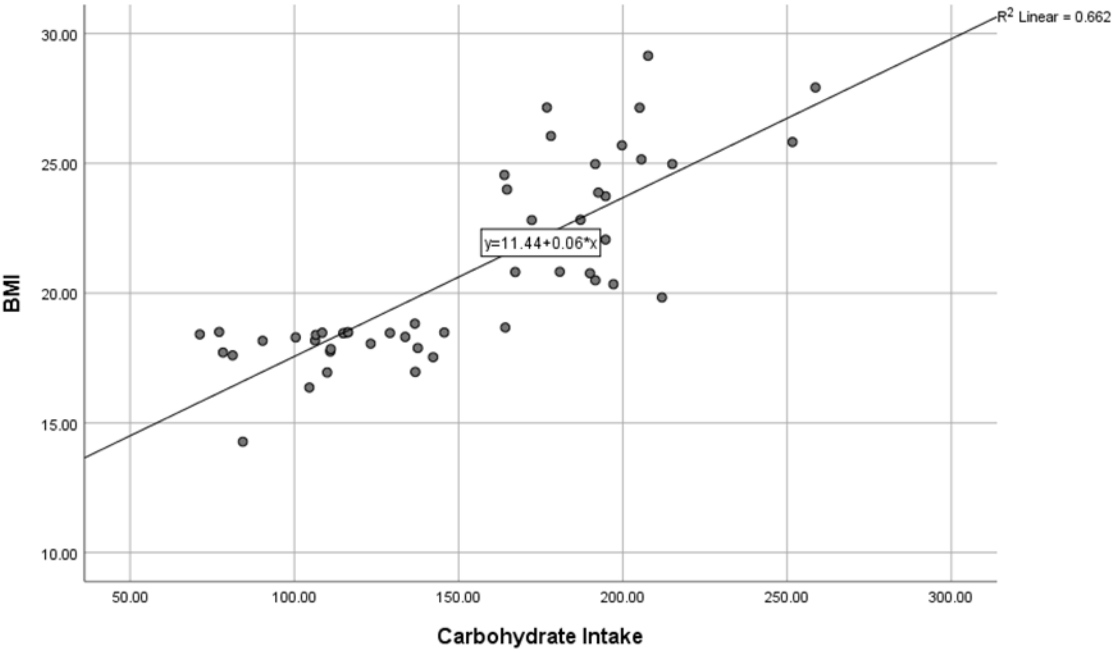
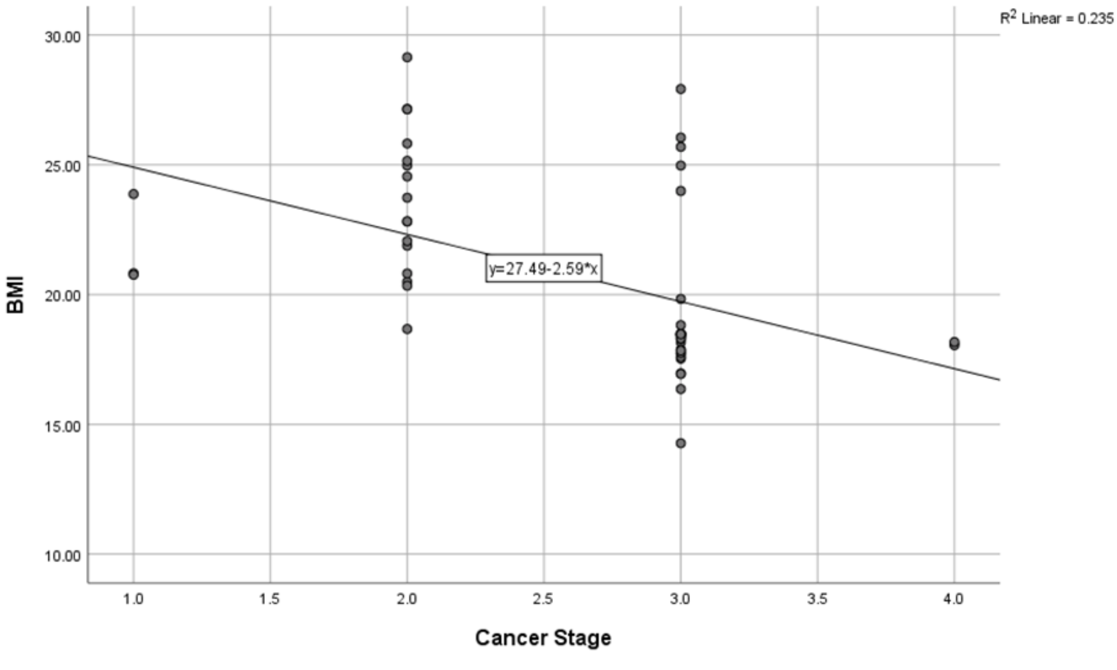


p-value=0,000 *ρ*=0,812

Figure 4. Scatter plot graph of the relationship between carbohydrate intake and BMI

Carbohydrates and fats serve as energy sources. If carbohydrate and fat intake are inadequate, the body will use protein as its primary energy source, which can lead to muscle loss and a decrease in lean body mass (Elinder et al., 2017). Furthermore, protein plays a crucial role in muscle formation. Inadequate protein intake can inhibit muscle protein synthesis, leading to a decrease in lean body mass, as muscle mass is a component of lean body mass (Deutz et al., 2011).



p-value=0,000 *ρ*=-0,606

Figure 5. Scatter Plot Graph of the Relationship between Cancer Stage and BMI

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Based on the Spearman-rank test analysis, a p-value of 0.000 (<0.05) was obtained, indicating a significant relationship between cancer stage intake and BMI. The correlation coefficient value of -0.606 indicates a strong relationship with a negative value indicating that the higher the cancer stage, the lower the patient's BMI. Based on the scatter plot graph (Figure 5), it is known that the data distribution forms a straight prediction line from the top left to the bottom right, indicating that the higher the cancer stage, the lower the patient's BMI.

The results of the study showed a significant relationship between cancer stage and BMI (ρ=-0.606). The increased risk of malnutrition experienced by patients with advanced cancer stages (stages IIIA-IVC) is caused by metabolic changes that occur in patients, causing an increase in nutritional needs but not balanced by adequate intake. Stage III or more indicates that cancer cells have metastasized to other tissues or organs of the body so that incoming nutrients tend to be used by cancer cells for their growth (Amin et al., 2017). As a result, healthy cells become less nutritious to carry out their normal functions. If this condition continues, energy reserves will be completely depleted, resulting in a decline in nutritional status.

Loss of appetite is a major cause of decreased food intake in cancer patients (Hariyanto and Kurniawan, 2021). Furthermore, cancer treatments, including chemotherapy, cause persistent nausea, vomiting, and diarrhea, which can trigger food aversions. Other factors that can contribute to decreased food intake in cancer patients include treatment-induced symptoms such as fatigue, depression, and pain, as well as tumor-induced symptoms such as cachexia, bloating, and early satiety (van der Werf et al., 2018).

CONCLUSION

The study shows that the average percentage of energy, protein, and carbohydrate intake is considered a severe deficit, while the average percentage of fat intake was considered a moderate deficit. There are significant relationship between macronutrient intake (energy, protein, fat, and carbohydrates) and cancer stage on the BMI of cancer patients undergoing chemotherapy at KHZ Mustafa Regional Hospital. Based on these findings, cancer patients undergoing chemotherapy are advised to pay more attention to the adequacy of their daily macronutrient intake. Hospitals are expected to improve regular and continuous monitoring of patient nutritional status by nutritionists before, during, and after chemotherapy cycles.

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