

## **Carbohydrate Intake is Associated with Learning Concentration among High School Students in Jember Regency, East Java Province, Indonesia**

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### **Abstract**

Low learning concentration will have impact on low academic performance. This study aims to determine the relationship between learning concentration and several factors and to find the most dominant factor in the students of SMAN 1 Jember. In this study, learning concentration was the dependent variable, while breakfast habits, nutrient intake (energy, carbohydrates, protein, fat, iron, zinc, vitamin B12, vitamin C), sleep quality, and physical activity were independent variables. This research is a quantitative study with cross-sectional design. This study conducted in June 2021 at SMAN 1 Jember with a total of 200 respondents who were selected using the quota sampling method. Data were collected through filling out online questionnaires. The data obtained were analyzed using univariate, bivariate analysis using chi-square, and multivariate analysis using multiple logistic regression. The results show that 52.5% of the respondents had a high learning concentration. The results also show that breakfast habits ( $p=0,016$ ), energy intake ( $p=0,037$ ), carbohydrates intake ( $p=0,000$ ), and sleep quality ( $p=0,020$ ) are related to learning concentration among adolescents. The results of multivariate analysis showed that carbohydrate intake was the dominant factor associated with learning concentration in adolescents.

Keywords: Learning concentration, adolescents, high school student, carbohydrates intake

### **Abstrak**

Rendahnya konsentrasi belajar berdampak terhadap rendahnya prestasi akademik. Penelitian ini bertujuan untuk mengetahui hubungan konsentrasi belajar dengan beberapa faktor dan menemukan faktor paling dominan pada siswa SMAN 1 Jember. Pada penelitian ini, konsentrasi belajar adalah variabel dependen, sedangkan kebiasaan sarapan, asupan gizi (energi, karbohidrat, protein, lemak, zat besi, seng, vitamin B12, vitamin C), kualitas tidur, dan aktivitas fisik adalah variabel independen. Penelitian merupakan penelitian kuantitatif desain cross-sectional. Pengambilan data dilakukan pada bulan Juni 2021 kepada 200 siswa-siswi kelas X dan XI SMAN 1 Jember yang dipilih menggunakan metode quota sampling. Data diperoleh melalui pengisian kuesioner secara daring (online). Data yang diperoleh dianalisis secara univariat, bivariat menggunakan chi-square, dan multivariat menggunakan uji regresi logistik ganda. Hasil menunjukkan bahwa 52,5% responden memiliki konsentrasi belajar tinggi. Hasil juga menunjukkan bahwa kebiasaan sarapan ( $p=0,016$ ), asupan energi ( $p=0,037$ ), asupan karbohidrat ( $p=0,000$ ), dan kualitas tidur ( $p=0,020$ ) berhubungan dengan konsentrasi belajar pada remaja. Hasil analisis multivariat menunjukkan bahwa asupan karbohidrat merupakan faktor paling dominan yang berhubungan dengan konsentrasi belajar pada remaja.

Kata kunci: Konsentrasi belajar, remaja, siswa SMA, kebiasaan sarapan, asupan karbohidrat

## Introduction

According to the Global Human Capital Report of the World Economic Forum (2017) which examines the quality of human resources in 130 countries, Indonesia is ranked 65th where on average, the quality of Indonesian human resources is still relatively low. Improving the quality of human resources can be done by optimizing the learning process of children and adolescents during the school period, where the factor that can increase the success of the process is to have a good concentration of learning (1).

Low student learning concentration will lead to low understanding of the material and in the end, will also have an impact on low learning achievement (2,3). Based on research conducted by Lentini (4) on adolescents aged 15-19 years in Surakarta it was found that 48.25% had low learning concentration. This is in line with the research by Lestari et al., (5) on vocational youth in Magelang Regency where 64.8% of students have poor learning concentration.

Breakfast gives the body nutrients after getting up in the morning to work, think, perform physical activity to the fullest (6). Gajre et al., (3) stated that breakfast habits have a positive effect on attention concentration, memory, and school achievement. On the other hand, the nutritional content of foods consumed daily such as breakfast, lunch, and dinner also is an important thing that must be considered because the intake of quality food will have an impact on the optimal performance of the body's organ systems and allow the fulfillment of daily nutritional needs. This is supported by a study by Gibson (7) which states that all macronutrient nutrients can provide energy, with different priorities and target organs, such as the brain

which is the main organ in determining a person's concentration ability, carbohydrates will play a role in providing glucose as the main energy source, proteins will provide precursors for the synthesis of neurotransmitters and make their receptors and fatty acids will provide the structural basis for nerve cell membranes.

In addition to breakfast and intake, sleep quality also affects learning concentration. Kumar et al., (8) revealed that adolescents with poor sleep quality will experience decreased concentration and inability to carry out daily activities. The next factor is physical activity that can increase cerebral blood flow and circulating levels of norepinephrine and endorphins, which positively affect mood, self-confidence, and concentration.

SMAN 1 Jember is a school located in the city center of Jember Regency. Ba et al., (9) found that adolescents in urban areas had a higher percentage of not eating breakfast than adolescents in rural areas due to differences in lifestyle. Therefore, this research was conducted at SMAN 1 Jember because of the high risk of not getting used to doing breakfast so that they have low learning concentration. In addition, research on learning concentration in high school adolescents in Indonesia is still limited, especially in Jember Regency which is also still not available, so researchers are interested in researching the relationship between breakfast habits, nutritional intake, and other factors with learning concentration in adolescent students. SMAN 1 Jember.

## Methods

This research is a quantitative study using a cross-sectional study design because it can make direct observations of an event, collect data that takes a short time, and gives quick results. The study

was conducted on students of grade 10 and 11 at SMAN 1 Jember. The research inclusion criteria were students who were registered to actively study in the 2020/2021 academic year, were present when data collection took place and were willing to fill out the questionnaire and for the exclusion criteria were students who were selected as respondents to the questionnaire trial, students who were sick, students who underwent a diet program, and students who are under the influence of drugs. The sampling method is quota sampling because it is easy to do to describe a population and is cost-effective.

The number of samples in the study was calculated using the two-proportion difference hypothesis test formula with the following formula:

$$n = \frac{\{Z_{1-\alpha/2}\sqrt{2P(1-P)} + Z_{1-\beta}\sqrt{2P(1-P_1) + (P_2(1-P_2))}\}^2}{(P_1 - P_2)^2}$$

n = Number of samples  
 $Z_{1-\alpha}$  = Z value in the confident interval (CI) of 95% ( $1-\alpha$ ) = 1,96  
 $Z_{1-\beta}$  = Test power of 90% = 1,28  
 $P$  =  $(P_1 + P_2) / 2$   
 $P_1$  = The proportion of low learning concentration in students who are not used to breakfast  
 $P_2$  = The proportion of low learning concentration in students who are used to breakfast

Research data collection is carried out online. The questionnaire link was distributed to all students in 11 selected classes totalling 374 students. The number of students who filled out the questionnaire was 320 students so that a response rate of 85.5% was obtained. Then the number of students who follow the zoom is 207 students so that the response rate is 64.7%, then the number of students who collect weekday and weekend food records is 200 students so that the response rate is 96.6%. Thus, the total number of samples that fit the research criteria amounted to 200 students.

## Results

The results showed that 59.5% of respondents came from grade 10 and 40.5% from grade 11. Most of them are female (67.5%) and the rest are male (32.5%). Then for the father's education level, as much as 64.5% have a college education level, followed by SMA (32%), Junior High School (2%), and Elementary School (1.5%). At the mother's education level, most of them also have a college education level (61%), then SMA (33.5%), junior high school (4%), and elementary school (1.5%). Most of the respondents have a high learning concentration as much as 52.5% and the rest have a low learning concentration of 47.5%.

**Table 1. Analysis of the Relationship between Independent Variables and Dependent Variables among Student of SMAN 1 Jember in 2021**

Independent Variable	Learning Concentration				Total		P-value	OR (95% CI)
	High		Low		N	%		
	n	%	N	%				
<b>Breakfast Habit</b>								
Used to breakfast	61	61.6	38	38.4	99	100	0.016*	2.08 (1.18-3.66)
Not used to breakfast	44	43.6	57	56.4	101	100		
<b>Energy Intake</b>								
Adequate	47	62.7	28	37.3	75	100	0.037	1.94 (1.08-3.48)
Inadequate	58	46.4	67	53.6	125	100		
<b>Carbohydrate Intake</b>								
Adequate	35	77.8	10	22.2	45	100	0.000*	4.25 (1.97-9.19)
Inadequate	70	45.2	85	54.8	155	100		
<b>Protein Intake</b>								
Adequate	27	44.3	34	55.7	61	100	0.164	0.62 (0.34-1.14)
Inadequate	78	56.1	61	43.9	139	100		
<b>Fat Intake</b>								
Adequate	39	51.3	37	48.7	76	100	0.907	0.93 (0.52-1.64)
Inadequate	66	53.2	58	46.8	124	100		
<b>Iron Intake</b>								
Adequate	2	25	6	75.0	8	100	0.219	0.29 (0.06-1.46)
Inadequate	103	53.6	89	46.4	192	100		
<b>Zinc Intake</b>								
Adequate	9	52.9	8	47.1	16	100	1.000	1.02 (0.38-2.76)
Inadequate	96	52.5	87	47.5	184	100		
<b>Vitamin B12 Intake</b>								
Adequate	11	44.0	14	56.0	25	100	0.487	0.68 (0.29-1.57)
Inadequate	94	53.7	81	46.3	175	100		
<b>Vitamin C Intake</b>								
Adequate	15	57.7	11	42.3	26	100	0.720	1.27 (0.55-2.93)
Inadequate	90	51.7	84	48.3	174	100		
<b>Sleep Quality</b>								
Adequate	44	64.7	24	35.3	68	100	0.020*	2.13 (1.17-3.90)
Inadequate	61	46.2	71	53.8	132	100		
<b>Physical Activity</b>								
Adequate	13	50.0	13	50.0	26	100	0.950	0.89 (0.39-2.03)
Inadequate	92	52.9	82	47.1	174	100		

**Table 2. Multivariate Analysis Result**

Variabel	Coef B	P-value	OR	95% CI
Breakfast habit	0.647	0.034	1.909	1.049-3.474
Carbohydrate intake*	1.541	0.000	4.670	2.020-10.795
Protein intake	-0.791	0.023	0.453	0.229-0.895
Sleep quality	0.650	0.048	1.916	1.006-3.650

## Discussion

The results of the study at SMAN 1 Jember showed that students who had a high learning concentration were 52.5% and a low learning concentration was 47.5%. This is in line with Lentini's research (4) on high school / vocational school students in Surakarta where as many as 51.75% of students have high learning concentration. The average DSST score of the respondents was  $42.86 \pm 15.63$ . Environmental conditions that are not conducive when conducting concentration tests through the zoom platform that cannot be controlled by researchers can be one of the contributing factors. This is in line with Lipdyaningsih et al., (10) which states that there are two factors that affect the concentration of learning in children, namely internal factors and external factors. Internal factors can be in the form of disturbances from the child himself such as feelings of restlessness, anxiety, fear, irritation, and the condition of body fitness. External factors in the form of an environment that is not conducive such as crowded and noisy (10). In addition, a poor internet connection during the concentration test can also cause students to experience technical problems during the test, such as a share screen that doesn't appear, doesn't move, or takes a long time to change. According to Muchtar et al., (11), experience and knowledge factors also affect concentration, whether students have previously taken a concentration test or not because students will focus on objects whose patterns cannot be recognized so that students' experience and knowledge can facilitate concentration.

The results of statistical tests showed that there was a significant relationship between breakfast habits and learning concentration in SMAN 1 Jember students where as many as 61.6% of

students who used to eat breakfast had high learning concentrations, with a p-value of 0.011. This is in line with research by Lentini (5) and Irfan (12) where there is a significant relationship between breakfast habits and thinking concentration. The energy obtained through breakfast will be used by the brain to improve the learning process. The 10 to 12-hour gap between dinner and breakfast can affect cognitive abilities. This is because a gradual decrease in glucose and insulin levels can affect various aspects of cognitive function such as attention, concentration, and memory. People who habitually eat breakfast, tend to have a lower desire to eat and higher basal metabolism. On the other hand, although children who do not eat breakfast can meet their daily nutritional needs through eating during the day, the chances of children not attending school and not being able to concentrate in class in the morning are greater because they are hungry in the morning (13).

Based on statistical tests, it was found that there was a significant relationship between energy intake and learning concentration in SMAN 1 Jember students with a p-value of 0.026. This result is in line with the research by Wardoyo & Mahmudiono (14) which also found a significant relationship between energy intake and learning concentration. Energy is essential for concentration and participation in school activities, so children whose stomachs are empty and hungry at school, whether due to skipping breakfast or not eating enough, will find it difficult to pay attention and complete assignments (15). This can be because energy is needed by the body for metabolic, cellular, and mechanical work such as breathing, heartbeat, and muscle work, all of which require energy and produce heat. When a person fails to get enough energy intake,

cognitive capacity will be impaired and the brain does not have enough fuel for attention, concentration, and learning (13).

Based on the analysis carried out, the results obtained a p-value of 0.000, meaning that there is a significant relationship between carbohydrate intake and learning concentration in SMAN 1 Jember students. These results are supported by research conducted by Wardoyo & Mahmudio (11) and Wasyluk, et al., (16) which revealed that breakfast with carbohydrates can affect concentration and memory. Glucose is the main source of energy for the brain. Glucose is needed as a precursor for the synthesis of neurotransmitters such as serotonin, noradrenaline, and acetylcholine (17). Several studies have shown that inadequate glucose intake can result in a significant decline in mental function and hypoglycemia that can affect brain function and cognitive performance (17,18). This is due to a decrease in the availability of glucose (hypoglycemia) which will affect brain function because it can interfere with the production of adenosine triphosphate (ATP) and the supply of precursors for neurotransmitter synthesis so that it can result in a decrease in concentration (19).

The results of the analysis also showed that there was no significant relationship between protein intake and student concentration at SMAN 1 Jember with a p-value of 0.122. This is in line with the research of Mawarni & Simanungkalit (20) which found that protein intake did not have a significant relationship with student achievement. Learning achievement itself is directly proportional to learning concentration so students who have medium and high learning concentrations will also have better academic achievements than students with low learning concentrations (5). Lieberman (19) in his

research states that to work optimally, the central nervous system requires a sufficient number of amino acids found in protein sources. Amino acids such as tryptophan, tyrosine, histidine, and arginine are used by the brain for the synthesis of various neurotransmitters and neuromodulators. The tryptophan, which is a precursor to serotonin, is an essential amino acid that is rarely found in food. Tryptophan can be found in foodstuffs such as meat and its products, grain products, milk, dairy products, vegetables, and eggs (21). Intake of less tryptophan is directly proportional to the production of serotonin. Low levels of serotonin can lead to cognitive disorders such as poor concentration, memory loss, and difficulty making decisions (22). So, even though protein intake is adequate, the tryptophan content contained in protein source foods is different so the relationship between protein intake and learning concentration cannot show a significant relationship.

The results of statistical tests also showed that there was no significant relationship between fat intake and learning concentration in SMAN 1 Jember students with a p-value of 0.793. This is in line with the research by Yunita & Nindya (34) which found that there was no significant relationship between fat intake and student concentration. Lipdyaningsih et al., (10) in their research state that learning concentration is influenced by two factors, namely internal and external. Internal factors can be in the form of disturbances from the child himself such as feelings of restlessness, anxiety, fear, irritation, and the condition of body fitness. External factors in the form of an environment that is not conducive such as crowded and noisy (19). This is in line with the limitations of this study, where the retrieval of research data is carried out virtually via zoom, making

environmental control difficult to do. As a result, the possibility for external factors to influence the concentration of learning is also greater.

Based on the results of statistical tests, obtained a p-value of 0.112, which means that there is no significant relationship between iron intake and learning concentration in SMAN 1 Jember students. This result is not in line with the research of Yunita & Nindya (34) but is in line with the research of Ebenezer et al., (24) and Istianah & Famila (25). The absence of a significant relationship between iron intake and learning concentration can be caused by the condition of respondents who consume less iron intake, have not yet reached the stage of iron deficiency anemia. This is because iron can affect learning concentration when the body lacks iron, causing anemia and as a result of someone experiencing anemia there is a decrease in physical performance, work capacity, decreased immune function, and the ability to concentrate (1,16,26,27).

Based on the results of statistical tests obtained a p-value of 0.97 where there is no significant relationship between zinc intake with learning concentration in SMAN 1 Jember students. These results are in line with the research of Warthon-Medina et al., (28) and Boeke et al., (29). According to Boeke et al., (29) previous studies were able to show a significant relationship between zinc intake and children's cognitive abilities because these studies used a different concentration test than the one used, so they could produce different results. In addition, zinc deficiency can also reduce hemoglobin formation and erythrocyte production, resulting in anemia (30). This anemia will result in decreased physical performance, work capacity, decreased immune function, and the ability to concentrate (18, 26). Thus, it is

possible that respondents with low zinc intake did not reach the stage of anemia so the relationship between zinc intake and learning concentration resulted in a non-significant relationship (35).

The results of statistical tests found that there was no significant relationship between vitamin B12 intake and learning concentration in students of SMAN 1 Jember ( $p = 0.363$ ). This is supported by research by Nguyen et al., (31) and Boeke et al. (29). According to Boeke et al., (29) no significant relationship was found between vitamin B12 and concentration because these studies used different concentration tests, which could produce different results. In addition, research limitations such as taking food record data virtually via WhatsApp can affect the estimated portion of food consumed by respondents because portions can only be seen through photos without direct examples (food models).

The results of statistical tests showed that there was no significant relationship between vitamin C intake and learning concentration in students of SMAN 1 Jember ( $p=0.570$ ). This result is not in line with the research of Yunita & Nindya (34) but is in line with the research of Istianah & Famila (25) which found no significant relationship between vitamin C intake and learning concentration. This can be caused by differences in the absorption of vitamin C in respondents so that the amount of vitamin C intake alone is not able to describe the relationship between vitamin C intake and learning concentration (31). In addition, other factors may influence study concentration more, such as breakfast habits (1, 20, 25,32) and energy and carbohydrate intake (27,33).

The results of the statistical test showed that there was a significant relationship between sleep quality and

student concentration at SMAN 1 Jember with a p-value of 0.013. This is in line with research by Novita et al.(34). While awake, the body accumulates a sleep debt that can only be repaid through sleep. This is regulated by a mechanism in the body called the sleep homeostat, which controls the body's drive to sleep. If a person has a greater sleep debt, then the sleep homeostat will tell the body that it needs more sleep (35). Therefore, poor or irregular sleep can lead to possible impaired cognitive and psychological functioning as well as a general deterioration of physical health (36). In a person who has poor sleep quality, one area of the brain will die, while another will be overworked to repair the deteriorating performance. The part of the brain that is overworked is the part involved in working memory, planning, attention, and verbal fluency so it will make a person sleepy and unable to concentrate the next day. Therefore, this part of the brain is strongly influenced by sleep quality and will not be able to work as well as when it has good quality sleep (7).

The results of statistical tests showed a p-value of 0.784, which means that there is no significant relationship between physical activity and learning concentration. This is not in line with the research of Fedewa (6) and Páez-Maldonado et al., (34), but is in line with Yu et al., (36) who found that there was no significant relationship between the level of physical activity and attention/concentration, memory, verbal skills. Too much physical activity generally drains energy so it affects concentration on academic activities (36,37). In addition, data retrieval, carried out during a pandemic, can affect results because it can make it more difficult to find statistically meaningful results.

Table 2. is the final result of

multivariate modeling, showing that the variables related to learning concentration are breakfast habits, carbohydrate intake, protein intake, and sleep quality because they have a p-value <0.05. It can be concluded that the independent variable which is the most dominant factor related to the learning concentration of SMAN 1 Jember students is carbohydrate intake. Carbohydrate intake has a significant p-value (0.000) and has the largest OR value (4.67) so students with sufficient carbohydrate intake have a 4.67 times greater chance of learning concentration than students with low carbohydrate intake. In protein intake, it was found that OR = 0.453 (OR<1), meaning that protein intake was a protective variable. In the interpretation  $1/0.453 = 2.207$ , it means that protein intake is less likely to have a high concentration of 2,207 times greater than adequate protein intake. In other words, less protein intake can reduce the impact of sufficient protein intake to have a high learning concentration.

Decreased availability of glucose (hypoglycemia) and insulin will interfere with brain function in producing adenosine triphosphate (ATP) and supply of neurotransmitter synthesis precursors, which in turn will have an impact on decreasing concentration (19). The vulnerability of the central nervous system to glucose in children is also different compared to adults, where the susceptibility of children to fluctuations in glycemia is higher, brain mass is greater compared to body mass and brain activity is higher per unit mass (37). The study also found that protein intake was less likely to have a high learning concentration 2,207 times greater than adequate protein intake. This can be caused even though the amount of protein intake is less, it is possible if the protein source consumed contains

sufficient essential amino acids needed by the brain so that with less protein intake, respondents can have high learning concentration. This is in line with the research of Lieberman (19) which states that it takes a sufficient number of amino acids in protein sources for the central nervous system to work optimally.

### Conclusion

Based on the results and analysis of research regarding the relationship between breakfast habits, nutritional intake, and other factors with learning concentration in students of SMAN 1 Jember 2021, the following conclusions were obtained:

1. A total of 52.5% of students of SMAN 1 Jember have high learning concentration and 47.5% have low learning concentration.
2. Comparison of the proportion of respondents who are larger in each independent variable, namely the variable accustomed to breakfast (50.5%), less energy intake (62.5%), less carbohydrate intake (77.5%), less protein intake (69, 5%), less fat intake (62%), less iron intake (96%), less zinc intake (92%), less vitamin B12 intake (87.5%), less vitamin C intake (87%), quality poor sleep (66%), and low physical activity (87%).
3. There is a significant relationship between breakfast habits, energy intake, carbohydrate intake, and sleep quality with learning concentration in students of SMAN 1 Jember in 2021.
4. There is no significant relationship between protein intake, fat intake, iron intake, zinc intake, vitamin B12 intake, vitamin C intake, and physical activity with learning concentration in students of SMAN 1 Jember in 2021.
5. Carbohydrate intake is the dominant factor in determining learning concentration in SMAN 1 Jember

students in 2021. Students with sufficient carbohydrate intake have a 4.67 times greater chance of having high concentrations than students with less carbohydrate intake.

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