

Macronutrient Intake and Academic Achievement in Budi Mulia Senior High School Bogor, West Java, Indonesia 2016

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Poor academic achievement during senior high school (SHS) will contribute to the failure of social and economic development in a country. However, SHS students' academic achievement in Indonesia is far behind other countries. This research aimed to examine differences on academic achievement based on nutritional status and other factors after controlling for relevant confounders. This study used cross sectional design including 15-18-year-old 130 students of Budi Mulia SHS Bogor, West Java. Data were collected from March-April 2016. Academic achievement was measured as well as height-for-age (HAZ), body mass index-for-age, dietary intake, frequency of breakfast, energy intake during breakfast, cardio-respiratory fitness, sleep duration, cognitive stimulation and motivation. Multivariate logistic regression models were used to find the dominant factor and other factors showing differences in academic achievement. There were 51.5% students who had poor academic achievement. The dominant factor determining students' academic achievement is cognitive stimulation ($P=0,002$; $OR=17$) after controlling other variables. Other factors giving differences on academic achievement were motivation, energy intake, cardio-respiratory fitness level and protein intake. HAZ, sleep duration and energy intake during breakfast were found as confounders. Academic success is associated with higher cognitive stimulation, achievement motivation, energy intake, cardio-respiratory fitness level and protein intake.

Keywords: *Academic achievement; cognitive stimulation; nutrient intake; nutritional status; senior high school.*

INTRODUCTION

Senior high school (SHS) plays an important role to develop a nation's future human resources (Quist, 2003 in Emmanuel, 2014). Poor academic achievement during this period will contribute to a failure in a nation's social and economic development (Chua and Mosha, 2015).

However, Indonesian students' academic achievement is still far behind other countries. Programme for International Student Assessment (PISA) 2012 showed that Indonesia was ranked 64th from 65 countries that participated, while Malaysia was in the 52nd position and Singapore was in the 2nd position.

There have been some previous studies about academic achievement in Indonesian senior high schools, including Azzaky (2015), Cahyani and Sidiartha (2015) and Pratiwi (2010) who found that there were 22.2%, 48.8% and 54% students had poor academic achievement in a SHS Bantarsari, Bali and Bekasi respectively. However, according to preliminary survey, there were 55% students who had poor academic achievement in Budi Mulia SHS, a private school in Kota Bogor (Agatha, 2016).

Based on previous studies, there are several factors that give differences in academic achievement, including nutritional status (Cahyani and Sidiartha, 2012; Rashmi et al, 2015; Spears, 2012; nutrient intake (Øverby, Lüdemann and Høigaard, 2013; Lustika, 2014; Malone, 2005; Melanson, 2008; Taras, 2005), breakfast (Gibson, 2002 in Melanson, 2008), cardio-respiratory fitness (Esteban-Cornejo et al 2014; Ross, Yau, Convit, 2015; Welk et al, 2010), sleep duration (Curcio, Ferrara, De Gennaro, 2006; Dewald, Meijer, Oort, Kerkhof, Bogels, 2010; Fallone, Owens, Deane, 2002; Wolfson and Carskadon, 2003), cognitive stimulation (Clearfield and Niman, 2012; Crookston, Forste, McClellan, Georgiadis and Heaton, 2014; Eamon, 2005) and motivation (Osei-Emmanuel, Adom, Josephine and Solomon, 2014). However, there have not been any studies that stated the dominant factor that gives difference on academic achievement from those factors in senior high school students. This research aimed to examine differences on academic achievement based on nutritional status and other factors after controlling for relevant confounders

METHOD

This cross sectional study was conducted between March and May 2016 in Budi Mulia SHS, Kota Bogor, West Java. Population target in this study was all of students in Budi Mulia SHS (n=695). Population study in this study is 10th and 11th graders, while 12th graders were not included because they were preparing National Examination 2016. Eligible subjects in this study were 10th and 11th graders who had complete mark of Mathematics, Bahasa Indonesia and English during last semester in 10-1, 10-3, 10-5, 11 science 2, 11-science-3 and 11-social-1 class (n=260). We excluded students who had a certain health condition, such as history of bone fracture and heart disease, so they cannot do the cardio-respiratory fitness test.

The minimum required sample size was 126. Subjects were recruited by systematic random sampling. Firstly, we collected students' number and name as sampling frame. The sampling frame was ordered from the smallest class (10 to 11-science and social). Secondly, we randomized a number as interval using a software. The number of 4 was used as interval. Finally, we randomized the sampling frame using interval of 4 until getting 130 students as our intended subjects.

Academic achievement was measured by using average score of Mathematics, Bahasa Indonesia and English during one last semester academic year 2015/2016 because these subjects are core subjects that determine students' achievement in another subjects (Syah, 2013). The results were classified as poor (a student's average score was below average of their friends' average score in the same grade) and good (a student's average score was equal or higher than their friends' average score in the same grade).

Nutritional status (HAZ) was measured using stadiometer and classified using WHO standard (WHO, 2007). Body weight was measured using digital scale. BMI for age was classified using WHO standard (2007).

Energy, protein, fat, carbohydrate and iron intake were measured by 2x24h food-recall using Byrne (2015) questionnaire. The results were classified using Gibson (2005): poor (nutrient intake was <77% AKG 2013) and enough (nutrient intake was $\geq 77\%$ AKG 2013).

Frequency of breakfast was measured by questionnaire from Hardinsyah (2012), while energy intake during breakfast was measured by 2x24h food-recall. Energy intake during breakfast was classified into poor (<20% AKG 2013) and enough ($\geq 20\%$ AKG 2013).

Cardio-respiratory fitness was measured by 20m shuttle run test. The result was converted into estimated VO₂ max using formula from Matsuzaka et al (2004): $VO_2 \text{ max} = 61,1 - 2,2 (S) - 0,462 (A) - 0,862 (BMI) + 0,192 (TL)$, where S is sex (0 for male, 1 for female), A is age (in years), BMI is body mass index (kg/m²) and TL is total lap. Female respondents were classified as fit if the score was ≥ 39 /minute mL kg, while male was ≥ 44 /minute mL kg.

Sleep duration is total duration of sleep during the night. It was measured by questionnaire from Lazaratou, Dikeos, Anagnostopulus, Sbokou and Saladatos (2005). The result was classified into short (<7 hours), enough (7-8 hours), long (>8 hours) (Seo and Young So, 2014).

Cognitive stimulation was measured by questionnaire from Eamon (2005) that were composed by six questions: number of books at home, instrumental possession, laptop/computer possession, after-hours education programs participation, frequency of after-hours education programs in a week and

duration of after-hours education programs in every session. The results were classified into low (total score <9) and high (total score \geq 9).

Motivation was measured by The Achievement Motivation Inventory from Pintrich and Schrauben, (1992) in Athman and Monroe (2004) that was composed by 20 statements that needed to be scored 1-4 using Likert's scale. The statements were composed by 4 aspects: self-efficacy, self-control, goal oriented and task value. The results were classified into low (total score <55) and high (total score \geq 55).

Chi-square and logistic regression tests were used to perform bivariate and multivariate analysis, respectively. This study was approved by the Ethics Committee of Public Health Faculty Universitas Indonesia.

RESULTS

Table 1 presents the baseline characteristics of participants. There are more than half (51.5%) participants who had poor academic achievement.

Variable	n	%
Sex		
Male	61	46.9
Female	69	53.1
Age		
15 years	12	9.2
16 years	62	47.7
17 years	48	36.9
18 years	8	6.2
Average = 16.4 \pm 0.7 years		
Class		
10-1	20	15.4
10-3	18	13.8
10-5	27	20.8
11 science 2	28	21.5
11 science 3	19	14.6
11 social 1	18	13.8
Academic achievement		
Below average	67	51.5
Good	63	48.5

Nutritional status (HAZ)		
Severely stunted	1	0.8
Stunted	9	6.9
Normal	120	92.3
Nutritional status (BAZ)		
Overweight	8	6.1
Possible risk of overweight	29	22.3
Wasted	9	6.9
Normal	84	64.6
Energy intake		
Poor	75	57.7
Enough	55	42.3
Protein intake		
Poor	50	38.5
Enough	80	61.5
Fat intake		
Poor	65	50
Enough	65	50
Carbohydrate intake		
Poor	98	75.4
Enough	32	24.6
Iron intake		
Poor	121	93.1
Enough	9	6.9
Frequency of breakfast		
Never	6	4.6
Not everyday	59	45.4
Everyday	65	50
Energy intake during breakfast		
Poor	104	80
Enough	26	20
Fitness status		
Not fit	68	52.3
Fit	62	47.7
Sleep duration		
Short	43	33.1
Long	6	4.6

Enough	81	62.3
Cognitive stimulation		
Low	44	33.8
High	86	66.2
Motivation		
Low	59	45.4
High	71	54.6

Table 2 presents the final model of logistic regression. Cognitive stimulation was the dominant factor that gives difference on academic achievement, where students who got high cognitive stimulation had good academic achievement 17 times higher than those who did not after controlling confounders. The other factors giving differences on academic achievement after controlling confounding variables (p value < 0.05) are motivation, energy intake, protein intake and cardio-respiratory fitness.

Table 2. Final model of logistic regression

	B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I. for EXP(B)	
							Lower	Upper
Cardio-respiratory fitness	1.590	0.793	4.021	1	0.045	4.90	1.036534	22.182
Protein intake	1.626	0.852	3.641	1	0.046	5.08	1.296867	26.992
HAZ	1.517	1.558	0.948	1	0.330	4.56	0.21515	96.539
Sleep duration	0.600	0.772	0.605	1	0.437	1.82	0.401505	8.272
Energy intake during breakfast	21.409	7098.603	9.100	1	0.998	1.98	0	
Energy intake	1.770	0.743	5.678	1	0.017	5.87	1.368967	25.158
Cognitive stimulation	2.922	0.921	10.063	1	0.002	17.43	3.055061	113.051
Motivation	2.598	0.763	11.598	1	0.001	13.44	3.013058	59.953
Constant	-8.847	2.209	16.034	1	6.22	0.000144		

DISCUSSION

There have been several studies about academic achievement in Indonesia; however, this is the first study that uses average of core subjects (Mathematics, Bahasa Indonesia and English) to measure academic achievement and distinguish the standard of score average between 10th graders and 11th graders. This is also the first study that involving senior high school students in a private school in Kota Bogor, West Java to examine the determinant factors of academic achievement in more holistic way. Limitation of this study is the use of non-standard questionnaire (Eamon, 2005) to measure cognitive stimulation because standard questionnaires such as StimQ Cognitive Home Environment or HOME questions are not suitable for subjects' age.

The percentage of students who had poor academic achievement was higher (51.5%) than the good ones (48.5%) which is similar to Pratiwi (2010). Previous studies by Rina (2008), Marpaung et al (2013) and Lustika (2014) found that there were higher percentage students who had good academic achievement than the poor ones. One reason for their finding was those studies used the average of one-time test scores.

There is no difference on academic achievement based on HAZ, which is similar to previous studies (Momongan, Punuh and Kuwatu, 2016; Septiani, 2012; Jaelani, 2014; and Ivanovic, Olivares and Castro, 1996 in Taras, 2005); however, there was a trend, where stunted students were more likely to have poor academic achievement (70%) compared to normal student (50%). The other previous studies (Separs, 2012; Rashmi et al, 2015) found differences on academic achievement based on HAZ. This different result might occur because majority (92.3%) of subjects was normal and the number of samples of this study was small.

There is no difference on academic achievement based on BAZ, which is similar to Juliani (2015) and Baxter et al (2013); however, all of overweight students (100%) had poor academic achievement compared to non-overweight students (48.3%).

Students who consumed enough energy had good academic achievement 6 times higher than those who had low energy intake after controlling confounding factors. This result supported previous studies (Septiani, 2012; Helland, Smith, Saarem, Saugstad and Drevon, 2003; Schmitt, 2010) that stated students who consume enough protein will have a better cognitive function that implies their academic achievement. Students who consume enough protein had good academic achievement five times better than those who had low protein intake after controlling confounding factors, which supported Hakim, Utami and Arum (2014); Septiani (2012); Maharani (2012). There was no

difference on academic achievement based on fat intake, which was similar to Shesilia (2011). Zhang, Hebert, Muldoon (2005) found by increasing 5% daily intake of PUFA would increase the cognitive function. In the other hands, the increase of cholesterol intake was associated with lower cognitive functioning. There was no difference on academic achievement based on carbohydrate intake, which was similar to Shesilia (2011). There was no difference on academic achievement based on iron intake, which supported Septiani (2012) and Jaelani (2014); however, there are many of previous studies found difference on academic achievement based on iron (Annas, 2011; Walker et al, 1998 in Taras, 2005; Helterman et al, 2001 in Taras, 2005; and Otero et al, 1999 in Taras 2005). All of previous studies that found a difference on academic achievement were using iron level in blood directly.

There was no difference on academic achievement based on frequency of breakfast using in a month, which was similar to Meiller et al (2012), Taras (2005), Bellisle (2004) and Rampersaud (2005). There was no difference on academic achievement based on energy intake during breakfast after controlling other variables, which was similar to Acham et al (2012), Jacoby et al (1996) and Ni Mhurchu et al (2013). The reasons that might explain this result are (1) breakfast itself was not enough to make a difference on academic achievement, it needed breakfast and lunch (Acham et al, 2012) and (2) breakfast only affected short-term hunger's students (Jacoby et al, 1996 and Ni Mhurchu et al, 2013).

Students who were fit had good academic achievement 5 times higher than those who were not fit after controlling confounding factors. This result was similar to Castelli, Hilman, Buck and Erwin (2007); Esteban-Cornejo et al (2014); and Torrijos-Nino et al (2014).

There was no difference on academic achievement based on sleep duration after controlling other variables, which supported Tonetti et al (2015) and Dewald et al (2010) that stated daytime sleepiness and sleep quality were giving more contribution to academic achievement than sleep duration.

Cognitive stimulation was the dominant factor that give difference on academic achievement, where students who got high cognitive stimulation had good academic achievement 17 times higher than those who had low cognitive stimulation. Books possession was the main aspect that differentiated those who had high and low cognitive stimulation. There were 89,6% students who were classified into high cognitive stimulation had more than 20 books at their home, while only 29,2% students in the low cognitive stimulation group that had so. The number of books at students' home is a fundamental aspect to encourage students' interest in reading as method to learn or entertain and increase the discussion between family members about what they read, so there will be more information to be explored by students (Bus and Ijzendoorn, 1995 in Evans, 2014; Dronkers, 1992 in

Evans, 2014; Persson 2012; Price 2012). In this research, students who have comics or novels in their houses tend to have a better cognitive stimulation and a better result in academic achievement.

Students who had high motivation had good academic achievement 13 times higher than those who had low motivation after controlling confounding variables. This result was similar to Gunanto (2002); Sugiyanto (2010); Pratiwi (2010); Abuameerh and Al Saudi (2012). The most contrast aspect between students with high and low motivation was task value. Task value is a part of intrinsic motivation that is defined as evaluation that is given by students about how interesting, useful and important one task that is given by teacher at school (Pintrich, Smith, Garcia and McKeachie, 1991 in Lawanto, Santoso and Goodridge, 2014).

CONCLUSION

More than half students (51,5%) in Budi Mulia SHS had poor academic achievement. Factors that did not give difference on academic achievement in bivariate analysis were HAZ, fat intake, carbohydrate intake, iron intake and frequency of breakfast. Confounding factors in this study were HAZ, sleep duration and energy intake during breakfast. Cognitive stimulation was the dominant factor that give difference on academic achievement after controlling confounders. The other factors that give differences on academic achievement after controlling confounding variables are motivation, energy intake, protein intake and cardio-respiratory fitness. Schools and parents should consider strategies how to improve those related factors for improving academic achievement.

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