

Fasting habits, sleep duration, energy availability, and chronic energy deficiency

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Fasting habits, sleep duration, energy availability, and chronic energy deficiency (CED) risk in female students

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Abstract

Fasting habits that are not followed by a healthy balanced diet along with sleep deprivation may cause low energy availability which increases the risk of Chronic Energy Deficiency (CED). This study was aimed to describe and analyze the relationship between fasting habits, sleep duration, energy availability and CED risk in Female Students. This study was an observational study conducted in Kyai Galang Sewu Islamic Boarding School. The total subjects were 98 female students age 18-24 that were selected by simple random sampling method. CED risk data was assessed using mid-upper arm circumference (MUAC). Fasting habits data was obtained from a questionnaire consisting related to type and duration of fasting, total fasting days and frequency of meals during fasting. Energy availability data was obtained by subtracting energy expenditure from energy intake divided by fat-free mass. Sleep duration data were obtained using the Sleep Timing Questionnaire. Univariate analysis was used to describe each of the variables. Bivariate analysis was performed using Rank Spearman test. Subjects who had CED risk was 44.9%. Subjects that practised fasting regularly was 76.5%, in which 51% of them fast on Monday and Thursday. A total of 49.3% subject often missed early breakfast. All subjects had low sleep duration and low energy availability. There was no relationship between the duration of fasting habits, total days of fasting, and sleep duration with energy availability ($p > 0.05$). However, there was a positive relationship between meal frequency during fasting and energy availability ($r = 0.36$, $p < 0.001$) and a positive relationship between energy availability and MUAC ($r = 0.39$, $p < 0.001$). Low energy availability was related to CED risk, while energy availability was influenced by the frequency of meals during fasting.

1. Introduction

The number of reproductive age women in Indonesia is the largest number among Southeast Asia countries, 65 million (Mujiati *et al.*, 2013). A large number of reproductive age women in Indonesia emphasize the importance of good nutritional status, especially in dealing with pregnancy. However, nutritional problems in reproductive age women in Indonesia are still relatively high.

One of the nutrition problems that usually occur in reproductive age women is Chronic Energy Deficiency (CED). CED is a condition where a person suffers from an imbalance of nutrient intake (energy and protein) that lasts for a long time (Muliawati, 2013). CED on reproductive-age women has some negative impacts, one of them was giving birth to low birth weight infant

(Ariyani *et al.*, 2012). Therefore, it is important to women at this age to prepare physically, and mentally to become a healthier mother.

The prevalence of CED risk in non-pregnant reproductive-age women in Indonesia based on the Mid-Upper Arm Circumference (MUAC) indicator was 14.5% in Indonesia (Kementrian kesehatan RI, 2018). The prevalence of CED risk in reproductive age women increased from 2007 to 2018. It increased from 30,9% to 36,3% among women aged 15-19 years old, and increase from 18,2% to 23,3% among women aged 20-24 years old (Kementrian kesehatan RI, 2018).

One group of reproductive age women in Indonesia which is susceptible to experience nutritional problems is female students in Islamic Boarding School (Santriwati). A study conducted at Al-Hidayah Islamic Boarding

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School in Grobogan, Indonesia showed results that 51.1% of students had underweight nutritional status caused by inadequate nutritional intake (Inayati, 2009). Other studies conducted at Salafiyah Kauman Pemalang Islamic Boarding School, Indonesia also showed results that 38% female students had poor nutritional status (Hidayah *et al.*, 2016). Furthermore, a study about food service system management at the Hubulo Islamic Boarding School in Gorontalo, Indonesia showed that the nutritional value of the food provided by school only met 76% of the total needs (Taqli *et al.*, 2014).

Low energy and nutrient reserves can cause CED in reproductive age women since adolescence and continue during pregnancy and breastfeeding (Ariyani, 2012). Energy availability represents the energy remaining for other metabolic processes to ensure proper physiological functions. Energy availability is the difference between energy intake and energy expended during exercise (relative to fat-free mass) (Ong and Brownlee, 2017). The value of energy availability 30 kcal/kg FFM/day is the threshold for the availability of energy needed for physiological functions (Papageorgiou *et al.*, 2018). Low energy availability usually occurs in athletes, where athletes have a lot of energy expenditure and are often not followed by adequate intake due to intake restrictions to maintain body weight (Sygo *et al.*, 2018).

Low energy availability is also possible to occur in female students because of the habits carried out by female students, including the high activity as students because they have to divide their time between formal education and religious activities in Islamic boarding schools, sleep deprivation, and fasting habits which is not followed by a healthy balanced diet. Female students who are still pursuing formal education must be able to divide their time between religious activities and formal education activities, thus they have a lot of activities. The greater the physical activity carried out, the greater the energy expenditure of a person (Westertep, 2013).

The activities of female students who live in Islamic boarding schools are dense thus students often have less time to sleep. Research on energy expenditure during sleep showed that energy expenditure significantly increased by ~32% when a person experienced sleep deprivation at night and significantly decreased ~4% during sleep recovery (Jung *et al.*, 2011). Other study showed that a low duration of sleep (4-5 hours a night) caused an increased in energy expenditure of 92 kcal or ~ 5% (Shechter *et al.*, 2013).

Another habit that is often practised by female students is sunnah fasting habits. Fasting can change the intake of nutrients due to the changes in diet. Fasting can increase insulin sensitivity, improve cognitive function,

prevent cancer, and improve cardiovascular function if it is followed by a good diet (Golbidi *et al.*, 2017). However, a study conducted at the Al-Itqon Bugen Islamic Boarding School in Semarang, Indonesia showed that female students who practised Monday and Thursday fasting habits consumed food that did not meet nutritional needs. The results showed that female students who practised Monday and Thursday fasting only had 77,87% of energy adequacy (Kustiyanti and Kartasurya, 2017).

There was no study conducted about energy availability among female students, how their habits may affect their energy availability, and how their energy availability may affect on CED risk. This study aimed to describe and analyzed the relationship between fasting habits, sleep duration, and energy availability in female students as well as the relationship between energy availability and CED risk.

2. Materials and methods

2.1 Design, location and time

This study was an observational study with a cross-sectional design and this research conducted in Kyai Galang Sewu Islamic Boarding School Semarang, Indonesia in April 2019. The entire study was approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Diponegoro/Dr. Kariadi Central General Hospital Number 162/EC/KEPK/FK-UNDIP/V/2019.

2.2 Samplings

The total number of subjects was 98 female students age 18-24 selected by a simple random sampling method. Inclusion criteria applied were female students who were active in the Kyai Galang Sewu Islamic Boarding School, did not have infectious diseases (typhoid fever, chronic diarrhea, tuberculosis, hepatitis, malaria, dengue fever), did not consumption supplements or drugs that can affect body composition, and agreed to be subject for this study.

2.3 Data collected

The independent variables in this study were fasting habits, sleep duration, and energy availability. The dependent variable was the CED risk. Data collected were subject characteristics data, fasting habits, sleep duration, energy availability, height, weight, fat-free mass, and mid-upper arm circumference.

The fasting habits data was obtained from a questionnaire to assess type and duration of fasting habits, total fasting days and frequency of meals during fasting. The type of fasting was kind of fasting which

was routinely performed by female students. The duration of fasting habits was the period length from female students started sunnah fasting up to the time when the data was collected. Total fasting days was the number of days female students practised sunnah fasting in a month. The frequency of meals during fasting was the number of main meals on a fasting day.

Energy availability data was obtained by subtracting energy expenditure from energy intake divided by fat free mass (FFM). Subjects were categorized have low energy availability if less than 30 kcal/kg FFM/day, normal if 30 kcal/kg FFM/day to 45 kcal/kg FFM/day, and high if >45 kcal/kg FFM/day (Márquez and Molinero, 2013). Energy intake data were obtained from 6 x 24 hours of food recalls and analyzed using Nutrisurvey 2007 software. Twenty-four hours food recalls was performed on four weekdays and two weekends to those who practised ngrowot fasting, naun fasting, or did not practice fasting, on three fasting days and three non-fasting days to those who practised Duad fasting, and two fasting days and four non-fasting days to those who practised Monday and Thursday fasting. Energy expenditure was calculated using the formula $3.5 \times \text{Body Weight} \times 5/1000 \times \text{Multiples of Basal Energy Metabolism (EMB)} \times \text{time}$ (Setyarsih et al., 2017). The total time of energy expenditure was derived from 24-hour physical activity obtained using 6x24-hour physical activity record questionnaire, which was collected simultaneously with the 6x24 hour-food recalls data collection. Fat-free mass data were obtained from measurements of body composition using BIA Tanita DC 360.

Sleep duration data were obtained using the Sleep Timing Questionnaire (STQ) (Ramadhaniah et al., 2014). The questionnaire contained questions related to sleep time in the last one month consisting of bedtime on weekdays and weekends. Subjects were categorized as

having less sleep if the duration of sleep was less than 7 hours, enough if the duration of sleep was ≥ 7 hours (Ramadhaniah et al., 2014). CED risk data was assessed using the Mid-Upper Arm Circumference (MUAC). Subjects were categorized as having CED risk if the value of MUAC was less than 23.5 cm (Kementrian kesehatan RI, 2018).

2.4 Data analysis

Normality data test was performed by the Kolmogorov-Smirnov test and univariate analysis was used to describe each of the variables. Bivariate analysis was performed using the Spearman Rank test.

3. Results

3.1 The characteristics of subjects

The median age of the subjects was 20 years and median mid-upper arm circumference (MUAC) of the subjects was 23.5 cm. The median duration of fasting habit was 11 months, median total fasting days was 6 days, while the median frequency of meals during fasting was 1 time per day. The characteristics of subjects can also be seen in Table 1. Median energy intake was 1,028.5 kcal, median energy expenditure was 951.5 kcal, the median fat-free mass was 33.7 kg, median energy availability was 1.85 kcal/kg FFM/day. Median sleep duration of subjects was 4 hours per day. The categories fasting habit, sleep duration, energy availability and CED status presented in Table 2. As many as 76.5% of subjects had fasting habit. The most common type of fasting was Monday and Thursday fasting which is 51% (n = 50) subjects. A much as 49.3% (n = 37) female students often missed early breakfast. All subject (100%) had low energy availability and sleep duration. Table 3 describes that a total of 44.9% female students was at risk of CED. The type of fasting habits and CED risk. Subjects who did not practice fasting but experienced

Table 1. Characteristics of subjects

Variable	Median	Minimum	Maximum
Age (years)	20	18	24
Weight (kg)	46.7	32.9	67.5
Height (cm)	152.5	139	169.5
MUAC (cm)	23.5	19	30.5
Fasting Habit			
Duration of Fasting Habit (month)	11	0	147
Total Fasting Days (day/month)	6	0	30
Frequency of Meals (time/day)	1	0	2
Energy Availability			
Energy Intake (kcal)	1028.5	815	1596
Energy Expenditure (kcal)	951.5	766	1285
Fat Free Mass (kg)	33.7	26.5	44.2
Sleep Duration (hours/day)	4	2	6.5

CED risk were 30.4%. Subjects who practised Monday and Thursday fasting and experienced CED risk was 44%, while subjects who practised Daud Fasting and experienced CED risk was 57.1%.

Table 2. Categories of fasting habit, sleep duration, energy availability and CED status

Category	n	%
Not Fasting	23	23.5
Fasting		
Monday and Thursday Fasting	50	51
Daud Fasting	14	14.3
Ngrowot Fasting	1	1
Naun Fasting	3	3.1
Monday and Thursday and Ngrowot Fasting	1	1
Monday and Thursday and Ayyamul bidh Fasting	6	6.1
Early Breakfast Habit		
Early Breakfast	38	50.7
Missed Early Breakfast	37	49.3
Energy Availability		
Low	98	100
Sleep Duration		
Low	98	100
CED status		
CED Risk	44	44.9
Normal	54	55.1

Table 3. Type of fasting and CED risk

Type of Fasting	CED Status			
	CED Risk		Normal	
	n	%	n	%
Not Fasting	7	30.4	16	69.6
Monday and Thursday Fasting	22	44	28	56
Daud Fasting	8	57.1	6	42.9
Ngrowot Fasting	1	100	0	0
Naun Fasting	2	66.6	1	33.3
Monday and Thursday, Ngrowot Fasting	0	0	1	100
Monday and Thursday, Ayyamul Bidh Fasting	4	66.6	2	33.3

*Monday and Thursday Fasting is one type of fasting which is carried out on Monday and Thursday; *Daud* fasting is a type of sunnah fasting, where fasting is intermittent ie daily fasting a day is not; *Naun* fasting is a type of fasting that is practised for a full year except during menstruation and days that are prohibited from fasting; *Ngrowot* fasting is one of fasting which is carried out by not consuming rice as a basic necessity as usual and replacing it with other carbohydrate sources such as cassava, corn; *Ayyamul bidh* fasting is a fast that is carried out every mid-month (13,14,15) of the *Hijri* based on the *Qomariah* calendar.

3.2 The relationship between fasting habits, sleep duration and energy availability

The relationship between fasting habits, sleep duration and energy availability can be seen in Table 4. There was no relationship between duration of fasting, total days of fasting and energy availability ($p = 0.34$; $r = -0.09$ and $p = 0.84$; $r = 0.02$ respectively). There was a relationship between the frequency of meals during fasting and energy availability ($p = 0.001$; $r = 0.385$), in which the less frequency of meals, the lower the energy availability. There was no relationship between sleep duration and energy availability ($p = 0.63$; $r = 0.05$).

Table 4. The relationship between fasting habits, sleep duration and energy availability

Variable	r	p-value ^a
Fasting Habits		
Duration of Fasting (month)	-0.09	0.34
Total Days of Fasting (day/month)	0.02	0.84
Frequency of Meals (time/day)	0.36	0.001*
Sleep Duration (hours/day)	0.05	0.63

^aRank Spearman Test. *Significant ($p < 0.05$)

3.3 The relationship between energy availability and mid-upper arm circumference (MUAC)

Table 5 describes that there was a relationship between energy availability and MUAC ($p < 0.001$; $r = 0.39$), in which the lower energy availability, the lower the MUAC.

Table 5. The relationship between energy availability and (MUAC)

Variable	r	p-value ^a
Energy Availability (kcal/kg FFM/day)	0.39	<0.001*

^aRank Spearman Test. *Significant ($p < 0.05$)

4. Discussion

Energy availability in female students was influenced by energy intake and energy expenditure. Energy intake was also influenced by many factors, included fasting habits. The fasting habit was one of the habits commonly practised by female students. Types of fasting carried out at Kyai Galang Sewu Islamic Boarding School were varied, including Monday and Thursday, *Daud*, *Ngrowot*, *Naun*, and *Ayyamul Bidh* fasting. Monday and Thursday fasting was the most widely practised among female students. The type of based on personal preference and was not based on regulation or from the Islamic Boarding School.

This study showed that the frequency of eating during fasting affected energy availability, the less frequency of main meals during fasting, the lower energy

availability of energy. They who run sunnah fasting often missed early breakfast and only eat a meal a day, thus their food intakes tends to be less than their needs. This finding was supported by research conducted by Al-Itqon Islamic Boarding School in Semarang in which students who practised Monday and Thursday fasting had lower energy adequacy compared to those who did not fast due to frequent missed early breakfast (Kustiyaniti and Kartasurya, 2017). Low energy intake could cause low energy availability (Ong and Brownlee, 2017). Research at Roudlatul Hidayah Islamic Boarding School also showed that lack of eating frequency caused energy adequacy could not be fulfilled, thus increased risk of low nutritional status such as Chronic Energy Deficiency (CED). It was recommended to have an eating frequency as many as 3 times a day of main meals and 2 times a day of snacks (Khusniyati et al., 2016).

However, this study could not show that duration of fasting and the total days of fasting in a month affected the energy availability. Some subjects have fasting habit for a long time before entering the Islamic Boarding School. A total of 65.3% of them had routinely carried out fasting for more than one year. Their main reasons for fasting were to improve patience and increased gratitude to God. Most of the students who had practised fasting for a long time had the habit of eating 2 meals a day, included early breakfast (suhoor). Therefore, long duration of fasting did not affect the energy intake adequacy as long as the food intake or frequency of eating during fasting was sufficient. Research by Desy Kustiyaniti stated that there was no difference in nutritional status between subjects who fast on Monday and Thursday with subjects who did not fast. Good nutritional status will be achieved if food intake during fasting remains good (Kustiyaniti and Kartasurya, 2017).

Fasting habits that affected energy were only the frequency of meals during fasting. This finding proved that sunnah fasting was good to be carried out both frequently and in a long period if it was followed by a good diet. Fasting actually provides many benefits such as increasing insulin sensitivity, improving cognitive function, preventing cancer, and improving cardiovascular function if followed by a good diet (Golbidi et al., 2017).

In addition, energy availability could also be influenced by energy expenditure that was influenced by sleep duration. The sleep duration for subjects was all low sleep duration. This was because they have to divide their time between religious activities in Islamic boarding school and learning activities on campus. Religious activities finished at 11:00 pm, but after that, they still had to work on college assignments thus they

had less sleep. However, the correlation test showed that there was no relationship between sleep duration and energy availability.

Based on existing theories, lack of sleep could increase a person's energy expenditure thereby reducing the value of energy availability if it was not balanced with adequate energy intake (Shechter et al., 2013; Melin et al., 2015). High energy expenditure could cause low energy availability. In this study, the lower sleep duration might increase energy expenditure since the subject who had low sleep duration on average had higher physical activity at night. The higher energy expenditure was due to multiple energy metabolism when sitting was higher than sleep. Therefore, the energy expenditure among subject who stayed up late was higher than students who slept early.

However, it turned out that subject who slept late tended to had early breakfast because they felt hungry when working on college assignments. Therefore, food intake was higher because they usually ate the meal before bedtime at around 1:00 to 2:00 a.m. Research in China showed that subjects who lack sleep had higher energy intake. Similarly, other studies by Marie-Pierre St-Onge, mentioned that subjects who had lower sleep duration experienced increase energy and fat intake (St-Onge et al., 2011). Higher energy intake was influenced by a decrease in leptin levels resulting in an increase in hunger and appetite (Gong et al., 2018). However, research by Novziransyah and Daulay (2018) showed that sleep duration was not related to student nutritional status. This study showed that lack of sleep might increase energy expenditure, but in another way around, it also increased energy intake. Therefore, it might explain why this study could not show the relationship between sleep duration and energy availability

Energy availability is the amount of energy in the body that is used for all physiological functions after calculating energy intake and energy expenditure for physical activity (Márquez and Molinero, 2013). The lower energy availability in this study mainly due to the low energy intake because they often missed the early breakfast. The statistical tests showed that there was a relationship between MUAC and energy availability, in which the lower energy availability, the smaller MUAC. Energy availability represents energy reserves for metabolic processes so that they can carry out physiological functions properly. Low energy and nutrient reserve could increase the risk of CED (Ong and Brownlee, 2017). Loucks stated that the low value of energy availability could cause a person to lose muscle mass or fat mass in his body. If it lasted long, it could reduce the body ability to carry out its physiological

functions properly (Holtzman and Ackerman, 2019). If there were continuous depletion of muscle mass and it was not accompanied with adequate food intakes, it would increase the risk of CED (Hadi et al., 2014).

A total of 44.8% of female students in this study had experienced CED risk. Subjects who did not practise a good diet were vulnerable to having a low nutritional status. Statistic analysis in this study showed that low energy intake had a significant correlation with the risk of CED. Therefore, it can be assumed that the energy intake was a component of energy availability risk in subjects. The measurement of energy status such as energy availability is an accurate and objective measurement and may reflect a compensation of CED compared to just using nutritional status measurement only (Williams et al., 2018).

4. Conclusion

A total of 44.9% of female students experienced the risk of CED. Subjects who had fasting habit was 76.5%, in which the Monday and Thursday fasting was the most practised by subjects (51%). All students had low sleep duration and low energy availability. There was a correlation between the frequency of meals during fasting and energy availability, but there was no relationship between duration of fasting, total days of fasting, sleep duration and energy availability. Energy availability was related to the risk of CED in subjects.

Conflict of interest

The authors declare no conflict of interest.

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