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Chronic energy deficiency prevention model for adolescent girls

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***Abstract*:**
Adolescence is a critical developmental phase marked by rapid physical growth, requiring adequate nutrition to support reproductive health. However, many adolescents fail to meet their nutritional needs, contributing to a high prevalence of Chronic Energy Deficiency (CED), particularly in developing countries like Indonesia. In Lampung, the prevalence of CED among women of reproductive age is 11.28%, with Islamic boarding schools (pesantren) reporting even higher rates, reaching 30%. This study examines the prevalence of CED at Darul 'Ulum Islamic Boarding School, Central Lampung, identifies contributing factors, and develops a prevention model. A total of 87 randomly selected female students across education levels participated. Data collection involved questionnaires assessing knowledge, attitudes, peer support, fasting habits, length of stay, food recall forms, and mid-upper arm circumference (MUAC) measurements. The findings indicate a 52% prevalence of CED, with significant correlations between CED and knowledge, attitudes, nutritional intake, education, physical activity, fasting habits, and peer support. Multivariate analysis highlights attitudes, fat intake, and length of stay as key factors. The study proposes a prevention model emphasizing behavior change, improved nutrition, and enhanced environmental management to reduce CED prevalence in Islamic boarding schools.

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INTRODUCTION

Adolescence signifies a transitional phase marked by rapid physical, cognitive, and psychosocial development (Lewis, 2022). The profound growth experienced during adolescence profoundly influences body composition and nutritional requirements, which are crucial for reproductive health and sustained growth, particularly in adolescent girls (Feskens et al., 2022). Maintaining optimal nutritional levels among adolescent girls is imperative for safeguarding reproductive health, preparing the next generation, and ensuring stable weight gain (Biswas, 2021).

The nutritional status of women of childbearing age and pregnant women is pivotal, considering that the quality of a child's life commences with the nutrition provided during the initial 1000 days (Indrio et al., 2022). Adolescents grappling with nutritional issues such as Chronic Energy Deficiency (CED) may experience adverse effects, including a diminished enthusiasm for learning and compromised physical health (Hargreaves et al., 2022). Young women encountering CED not only face immediate health challenges but also bear the long-term risk of becoming mothers at risk of delivering Low Birth Weight (LBW) babies (Thurstan et al., 2021).

The repercussions of stunting in toddlers extend to elevated disease susceptibility, diminished academic performance, reduced work productivity in adulthood, and an associated decline in income (Soliman et al., 2021). Given the far-reaching impact, preventative efforts targeting stunting should span from early adolescence to pregnancy (Nurhaeni et al., 2024). Essential components of adolescents' well-being, including diet and physical activity, play a pivotal role in sustaining health

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and ensuring adequate nutritional intake, covering energy, protein, iron, and calcium (Miller et al., 2020).

Numerous teenagers encounter challenges meeting their nutritional requirements, resulting in diminished physical activity, compromised fitness, and low hemoglobin levels (Cohen & Powers, 2024). In low- and middle-income countries, the prevalence of CED in women of reproductive age can be alarmingly high, exerting significant impacts on health and overall development (Paro et al., 2024).

Insufficient energy and protein intake in Indonesia often lead to CED (Wati et al., 2024). Globally, the prevalence of CED in adolescent girls is substantial, carrying a noteworthy risk of mortality associated with CED (Chakrabarty, 2023). Malnutrition poses a severe challenge that impacts the well-being of adolescents and future generations, necessitating preventative measures commencing in adolescence (Warf et al., 2020). Practical efforts to prevent CED and nutritional issues in adolescents markedly enhance their quality of life, mitigating negative impacts (Duan et al., 2024). Adolescence, as a transition from childhood to adulthood, involves rapid physical, cognitive, and psychosocial growth (Best & Ban, 2021).

Within this context, nutritional challenges, particularly CED, represent a formidable obstacle demanding attention and efficacious preventative measures (Di Bella et al., 2024). CED in adolescent girls is attributed to direct factors such as consumption patterns, nutritional status, insufficient energy and protein intake, and the presence of infectious diseases (Puspitasari et al., 2023). Indirect factors encompass poor socioeconomic status, physical activity, educational level, inadequate nutrition knowledge, attitudes, and age (Dagnew & Asresie, 2020; Febry et al., 2020; Maehara et al., 2019). Various studies indicate that factors like nutritional knowledge, nutritional attitudes, energy consumption levels, protein consumption levels, food type, macronutrient intake, iron intake, hemoglobin levels, meal frequency, food type, and quantity, and the Islamic boarding school environment can influence CED in young women. Preliminary research at the Darul 'Ulum Putri Islamic Boarding School indicates that around 58% of female students grapple with CED, with a prevalence surpassing 30%, classifying it as a severe health issue. This research aims to forecast the risk level of CED at the Darul 'Ulum Putri Islamic Boarding School and formulate a CED prevention model suitable for implementation, fostering energy prosperity for each female student.

METHOD

This research is observational research with a quantitative design using survey methods. This type of research is observational analytic with a cross-sectional approach, which aims to analyze the factors associated with CED among female adolescents at the Darul 'Ulum Islamic Boarding School in Central Lampung.

Sampling procedures

The sample is a representative part of the population selected using a particular method. The sampling method in this research uses probability sampling with a proportionate stratified random sampling technique, which provides an equal opportunity for each member of the population to be selected as a sample. This technique is used when the population is homogeneous and proportionally stratified. Samples were taken by measuring LILA in the research population to determine the number of female students who experienced CED at various levels of education.

Sample size, power, and precision

The sample must meet the inclusion and exclusion criteria, where the exclusion criteria avoid using inappropriate objects, while the inclusion criteria consider the research object. The sample size is determined using the Slovin formula, which calculates the minimum sample in a finite population survey to estimate population proportions. So, based on these calculations, the sample obtained for each level of education was 42 for junior high school level, 40 for high school level, and 5 for above high school level.

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Participant characteristics and research design

The population used in this research were all young women studying at the Darul 'Ulum Islamic Boarding School in Central Lampung. Based on Islamic boarding school data, the following is the number of female students at the research location:

Table 1. Number of female students at Darul 'Ulum Islamic Boarding School in Central Lampung

Level of education	Number of people	Percentage
Junior High School	312	48%
Senior High School	304	47%
Above High School	35	5%
Total	651	100%

Measures and covariates

Data collection in this research involved primary data and secondary data. Primary data was obtained through interviews, direct observation, and direct research. Data collection methods include interview techniques, with researchers collecting data on respondents' characteristics, socioeconomics, and eating patterns using a questionnaire. Apart from that, data collection also involves documentation to obtain initial data during preliminary research and the research process, including the number of female students at the Darul 'Ulum Islamic Boarding School in Central Lampung and measuring the LILA of female students. The data collection instrument includes using a questionnaire as an interview guide to collect information about respondent characteristics, knowledge, socioeconomics, consumption patterns, and consumption levels. In addition, CED status measurements are carried out using the LILA Tape, with predetermined steps. Data collection also involves 2x24 24-hour Food Recalls, carried out in two different 24-hour periods, to get an accurate picture of individual food consumption. The steps for collecting Food Recall data have also been explained in detail.

Independent variables are variables that influence or are the cause of changes or emergence of the dependent variable. The independent variables in this study are knowledge about CED, attitudes about CED, nutritional intake, family economic conditions, age, education, peer environment, physical activity, fasting habits, and length of residence. The independent variables in this study include knowledge about Cronic Energy Deficiency (CED), attitude towards CED, nutritional intake, family economic conditions, age, education, peer environment, physical activity, fasting habits, and length of stay. These independent variables encompass various aspects of knowledge, attitudes, nutritional practices, and socioeconomic and demographic factors affecting female adolescents at Pondok Pesantren Darul 'Ulum. Knowledge about CED is assessed through their level of knowledge and attitudes, measured through interviews using questionnaires with an ordinal scale. Additionally, the adequacy of nutritional intake such as carbohydrates, proteins, fats, and energy is also a focus, measured by gathering information through interviews using a 24-hour food recall form and compared with the Nutritional Adequacy Rate (NAR). This variable is measured on a ratio scale. Socioeconomic factors such as family income, age, and education are also considered and measured through interviews and questionnaires. The same goes for physical activity, peer environment, fasting habits, and length of stay in the boarding school, all measured on an ordinal or ratio scale. Collecting data from various independent variables is hoped that a comprehensive understanding of the factors influencing the nutritional status and lifestyle of female adolescents at Pondok Pesantren Darul 'Ulum can be obtained.

Data analysis

This research will analyze data using binary logistic regression, describing the relationship between the response variable (Y), the predictor variable (X), and the qualitative response variable. Data analysis will involve univariate analysis for the characteristics of the research variables, bivariate analysis using the Chi-Square test to test the relationship between two variables, and multivariate analysis using multiple linear regression with a stepwise method to determine the prediction model for CED prevention. Hypothesis testing is carried out to determine whether at least one variable significantly affects CED. The validity of the questionnaire is tested by ensuring the

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validity value of each answer is more significant than 0.3. At the same time, reliability is measured using the Cronbach Alpha technique, with a Cronbach Alpha value > 0.70, which is considered reliable.

This study underwent a strict ethical testing process and received approval from the Research Ethics Committee of the Faculty of Medicine, University of Lampung. Ethical testing was carried out to ensure that all aspects of the study, including methodology, implementation, and protection of participants, were by applicable research ethics principles, such as prioritizing the safety, confidentiality, and freedom of participants in providing informed consent. Thus, this study has scientific validity and meets moral and ethical standards that are recognized academically and professionally. This shows the researcher's commitment to maintaining integrity and responsibility in every research stage.

RESULT

Respondent descriptive

The table below shows that most of the subjects in this study had low nutritional status, with 60% experiencing Chronic Energy Deficiency (CED), as reflected by an average upper arm circumference of 22.1 cm. In addition, low knowledge and attitudes were also dominant, with 75% of subjects having inadequate knowledge and 85% showing less supportive attitudes. This suggests that this group of subjects may be malnourished and lack the information and support needed to improve their health status. Furthermore, age data shows that the majority of subjects were early adolescents (12-16 years) who may be more vulnerable to malnutrition and require special attention. High physical activity among subjects (79% reported heavy physical activity) and a less supportive social environment (54%) also highlight the potential for more significant health risks. Low levels of nutritional adequacy, especially in terms of energy, protein, and fat, add to the complexity of the problems faced by the subjects, emphasizing the need for better nutritional interventions and educational support to improve their overall condition.

Table 2. Respondent Descriptive

	Amount (n)	Max	Min	Mean	Percentage (%)
Nutritional Status (CED)					
Yes (≤ 23.5 cm)	52	23,5	18	22,1	60
No (> 23.5 cm)	35	31,5	24	25,8	40
Knowledge about CED					
Poor	75	57	19	41	86
Enough	11	71	62	65	12
Good	1	76	76	76	1
Attitude about CED					
Poor	74	60	35	48	85
Enough	12	69	60	63	14
Good	1	86	86	86	1
Age					
Early Adolescence (12-16)	65	16	12	14	75
Late Adolescence (17-25)	22	20	17	17	25
Physical Activity					
Heavy	69	2,397	2,002	2,206	79
Moderate	17	1,838	1,711	1,782	20
Light	1	1,609	1,609	1,609	1
Supportive peer environment					
Poor	47	3,36	2	3,03	54
Good	40	4,36	3,54	3,8	46
Length of Residence					
Less than 6 months	16	4	2	3	18
More than 6 months	71	12	71	49	82
Nutritional Adequacy Level					
Energy		94	11	47	

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	Amount (n)	Max	Min	Mean	Percentage (%)
Carbohydrate	87	150	12	46	100
Protein		109	13	49	
Fat		111	11	54	
Total	87				100

Univariate test

The table depicts relevant data for understanding the problem of Chronic Energy Deficiency (CED) and its associated factors in a group of participants. The first part of the table separates participants into two groups based on their arm circumference, namely those with arm circumference less than 23.5 cm (CED) and those with arm circumference greater than or equal to 23.5 cm (Not CED). Of the total 87 participants, around 60% experienced CED, while 40% did not experience CED. This indicates that most of the participants in this study faced severe nutritional problems.

Table 3. Univariate Test

	n	%
Nutritional Status (CED)		
< 23,5 cm (CED)	52	60
≥ 23,5 cm (not CED)	35	40
Total	87	100
Knowledge about CED		
Less	75	86
Enough	11	13
Fine	1	1
Total	87	100
Attitude about CED		
Less	74	85
Enough	12	14
Fine	1	1
Total	87	100

The distribution analysis of CED (Chronic Energy Deficiency) among female students revealed that 60% (52 individuals) experienced CED, while 40% (35 individuals) did not. Furthermore, knowledge regarding CED was predominantly low, with 86% of respondents categorized as having insufficient knowledge. The questionnaire results demonstrated misconceptions regarding essential nutrition principles, such as the significance of vitamins, minerals, and balanced diets. Similarly, attitudes toward CED were largely inadequate, with 85% exhibiting negative perceptions. The most common misunderstanding was equating normal body weight with sufficient energy intake. Additionally, a substantial proportion (25 respondents) preferred high-fat foods, which may contribute to unhealthy dietary habits. These findings underscore the necessity for targeted nutritional education and structured intervention programs within Islamic boarding schools.

Table 4. Univariate Test

Nutritional Adequacy Level	n	%
Energy		
Severe Deficit Level: <70%	79	91
Medium Level Deficit: 70-79%	5	6
Mild Level Deficit: 80-89%	2	2
Normal Level: 90-119%	1	1
Over Rate: ≥ 120%	0	0
Total	87	100

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Nutritional Adequacy Level	n	%
Carbohydrate		
Severe Deficit Level: <70%	79	91
Medium Level Deficit: 70-79%	4	5
Mild Level Deficit: 80-89%	2	2
Normal Level: 90-119%	1	1
Over Rate: ≥ 120%	1	1
Total	87	100
Protein		
Severe Deficit Level: <70%	77	89
Medium Level Deficit: 70-79%	4	5
Mild Level Deficit: 80-89%	3	3
Normal Level: 90-119%	3	3
Over Rate: ≥ 120%	0	0
Total	87	100
Fat		
Severe Deficit Level: <70%	64	73
Medium Level Deficit: 70-79%	12	14
Mild Level Deficit: 80-89%	4	5
Normal Level: 90-119%	7	8
Over Rate: ≥ 120%	0	0
Total	87	100

Nutritional adequacy refers to the average daily intake of essential nutrients required for optimal health, varying based on age, gender, body size, and activity level. Data were collected using a 2x24-hour food recall method through interviews, where enumerators recorded all consumed foods and beverages. These records were coded using food composition tables to determine nutrient content, including energy, protein, fat, and carbohydrates. The findings indicate severe energy deficits among 91% of female students, with only 1% meeting standard energy requirements. Similarly, 91% experienced a carbohydrate deficit, while 89% and 75% had severe protein and fat deficiencies. The analysis categorized food groups based on nutrient composition, including carbohydrates from cereals and vegetables, proteins from meat, fish, and legumes, and fats from oils and butter. These results highlight the urgent need for nutritional intervention in Islamic boarding schools.

Table 5. Univariate Test

	n	%
Family Income		
Less than MSEs	38	44
More than MSEs	49	56
Total	87	100
Age		
Early Teens (12-16)	65	75
Late Teenagers (17-25)	22	25
Total	87	100
Education		
Junior High School	42	48
Senior High School	40	47
Above high school	5	5
Total	87	100

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	n	%
Physical Activity		
Heavy	69	79
Currently	17	20
Light	1	1
Total	87	100
Peer environment		
Not enough	47	54
Good	40	46
Total	47	54
Physical Activity		
Heavy	69	79
Currently	17	20
Light	1	1
Total	87	100
Fasting habit		
Have a habit of fasting	60	69
Does not have the habit of fasting	27	31
Total	87	100
Long of stay		
Less than 6 months	16	18
More than 6 months	71	82
Total	87	100

Based on the respondents' data regarding parental income, the distribution of student's family income is relatively even, with 56% earning above the regional minimum wage (UMK) of Lampung Tengah (Rp2,444,079.29). The age distribution reveals that 75% are early adolescents (12–16 years), while 25% are late adolescents (17–25 years). 48% are at the junior high school level, 47% in senior high school, and 5% have completed higher education. Physical activity levels indicate that 79% engage in heavy activity, 20% moderate activity, and 1% light activity. Peer environment support is divided, with 54% reporting inadequate support and 46% receiving sufficient encouragement. The influence of peers varies, with the highest approval for reminders to wash hands before eating (mean 4.0, mode 5). Fasting habits show that 69% observe voluntary fasting. Lastly, 82% have resided in the pesantren for over six months.

Bivariate test

The study findings reveal a significant correlation between knowledge of Chronic Energy Deficiency (CED) and its occurrence among female students, with a p-value of 0.075, meeting the 90% significance threshold. Individuals with inadequate knowledge exhibited a higher prevalence of CED (61%), whereas none of those with good knowledge experienced the condition. This result aligns with prior research (Kamsiah et al., 2023), highlighting that insufficient knowledge about CED influences dietary behavior and nutritional intake, thereby increasing vulnerability to malnutrition. Limited access to nutritional education in pesantren environments exacerbates this issue. Additionally, inadequate dietary intake, particularly in energy and carbohydrates, was significantly associated with CED ($p = 0.023$ and $p = 0.066$, respectively) (Deshmukh et al., 2006; Petry et al., 2019). Therefore, improving nutritional knowledge, fostering positive attitudes, and ensuring adequate dietary intake are essential in mitigating CED among female students (Zuraida et al., 2020).

Interestingly, family income does not exhibit a statistically significant correlation with CED among female students, as evidenced by a p-value of 0.892, exceeding the 90% significance threshold. Notably, students from families earning above the regional minimum wage (UMK) in Lampung Tengah had a CED prevalence of 50%, whereas those with lower family incomes exhibited

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a higher prevalence of 67%. Although socioeconomic status is generally a determinant of nutritional well-being (Moya, 2020), pesantren regulations limit discretionary food purchases, restricting access to additional nutritious options. Educational attainment also correlated with CED (p = 0.073), where higher education levels were paradoxically linked to an increased risk, potentially due to sociocultural pressures influencing dietary behaviors (Marcone et al., 2020).

Moreover, the study highlights a relationship between physical activity levels and CED. The data indicates that individuals engaging in heavy physical activity are more likely to experience CED, with 59% (41 out of 69 individuals) affected. In comparison, 65% (11 out of 17) in the moderate activity group also experience CED. The p-value of 0.093 suggests a statistically significant relationship at the 0.10 significance level. The impact of physical activity on adolescent health is that while high-intensity exercise enhances bone density, inadequate nutritional intake may increase the risk of CED (Proia et al., 2021). Additionally, peer influence plays a critical role, as individuals with less supportive social environments exhibit a higher incidence of CED (Chen, 2024).

Multivariate test

The multivariate analysis was conducted following the bivariate analysis to examine the simultaneous influence of multiple independent variables on the dependent variable. This approach aimed to identify significant factors contributing to CED and develop a predictive model. A total of 13 independent variables were initially considered, of which 12 met the selection criteria with a significance level below 0.1. The stepwise regression method was employed to iteratively include or exclude variables based on their significance in constructing an optimal model.

Table 6. Multivariate test

Model		Unstandardized Coefficients		Sig.
		B	Std. Error	
1	(Constant)	25.099	0.280	0.000
	Knowledge about CED	1.143	1.396	0.066
	Attitudes about CED	2.205	2.018	0.047
	Carbohydrate Level	0.231	2.295	0.024
	Age	1.060	0.453	0.051
	Fasting	2.025	0.205	0.038
	Physical Activity	1.118	0.958	0.041
2	(Constant)	23.557	0.283	0.000
	Knowledge about CED	1.010	0.093	0.026
	Attitudes about CED	3.103	0.988	0.026
	Protein Level	0.284	2.247	0.027
	Energy Level	0.100	0.612	0.042
	Fat Level	1.036	0.190	0.050
	Age	2.129	0.985	0.027
	Education	3.106	0.867	0.088
	Physical Activity	5.141	1.170	0.045
3	(Constant)	23.640	0.297	0.000
	Knowledge about CED	1.010	0.100	0.021
	Attitudes about CED	2.040	0.379	0.006
	Protein Level	0.182	1.121	0.065
	Carbohydrate Level	1.059	0.313	0.055
	Energy Level	1.106	0.823	0.013
	Fat Level	3.085	0.705	0.083
	Education	0.118	1.002	0.019
	Physical Activity	0.081	0.797	0.028
	Fasting	1.014	0.142	0.087
	Length of Residence	2.087	0.824	0.012

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Three regression models were generated, with the third model selected due to its highest R-square value (69.6%), indicating that the included independent variables explained 69.6% of the variance in CED occurrence. The final model incorporated knowledge of CED, attitudes toward CED, adequacy levels of energy, carbohydrates, protein, and fat intake, education, physical activity, fasting habits, and length of stay.

The model equation was:

CED = 6.640 + 1.010X1 + 2.040X2 + 0.182X3 + 1.059X4 + 1.106X5 + 3.085X6 + 0.118X9 + 0.081X10 + 1.014X12 + 2.087X13.

Table 7. Model Determination

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.506	0.393	0.283	2.279
2	0.683	0.547	0.427	2.322
3	0.843	0.696	0.676	2.267

The findings highlight that increased knowledge and positive attitudes toward CED significantly contribute to its prevention. Nutritional sufficiency, particularly in energy, carbohydrates, protein, and fat, is crucial in mitigating CED risk. While education was a factor, its impact was relatively lower than others. Moreover, physical activity influences energy requirements, potentially exacerbating CED if not balanced with adequate intake. Future research should consider psychosocial factors such as mental health, social pressures, eating disorders, and cultural dietary norms, alongside the role of social media in shaping dietary behaviors. These elements may further refine interventions to reduce CED prevalence through a holistic approach integrating education, nutrition, and lifestyle modifications.

DISCUSSION

The CED incident among female students

Chronic energy deficiency (CED) is a condition where an individual experiences prolonged inadequacy of energy and protein, identifiable through an upper arm circumference (LILA) of less than 23.5 cm (Wati et al., 2024). The upper arm circumference indicates nutrient availability in the body, and in this investigation, 52 female students were identified as having CED based on LILA. CED not only persists as a stunting issue but also contributes to weakened immune systems, heightened susceptibility to infectious diseases, and compromised cognitive development in children (Gizaw et al., 2022). Therefore, conducting LILA assessments and implementing measures to prevent and treat CED is crucial to ensure the long-term health of individuals and mitigate its adverse impacts.

Relationship between Knowledge Status and CED

Knowledge about nutrition and health significantly influences an individual's eating patterns and nutritional status, especially concerning the challenge of chronic energy deficiency (CED) during pregnancy (Wati et al., 2024). This study reveals that approximately 90% of female students with CED have limited knowledge about CED and nutrition. Previous research underscores the pivotal role of knowledge in attaining favorable nutritional statuses (Astuti et al., 2022; Jovanović et al., 2023). However, augmenting knowledge alone is insufficient; practical training and comprehensive support, encompassing social and economic aspects, are imperative to assist female students at risk of CED in making healthy food choices and meeting their nutritional requirements. With this holistic approach, enhancing knowledge becomes crucial in addressing the issue of CED and other associated malnutrition problems in the female student population (Amoadu et al., 2024).

Relationship between Attitudes and CED

An individual's attitude is shaped by knowledge, beliefs, thoughts, personal experiences, mass media, culture, and emotions, influencing individual behavior (Toomey, 2023). female students with

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CED exhibit an unfavorable attitude toward nutrition, often resulting in an imbalanced and low-nutrient diet, including insufficient consumption of vegetables, fruit, fiber, and other essential nutrients crucial for maintaining bodily health (Nogueira et al., 2023). Additionally, excessive consumption of fast food, known for its high fat, sugar, and salt content and low fiber and essential nutrient content, can elevate the risk of health issues such as obesity, diabetes, and heart disease. Developing a positive attitude toward nutrition requires young women to heighten awareness of the food they consume, enhance nutritional knowledge, prioritize healthy foods, refrain from fast food consumption, and seek social support and nutritionist consultation to facilitate the adoption of a more balanced and health-supportive diet (Shine et al., 2022).

Relationship between Nutritional Status and CED

Carbohydrates serve as the primary energy source for the body, essential for physical activity (Rollo et al., 2020). female students with CED experience a severe carbohydrate deficiency, significantly impacting CED (Putri et al., 2024). Most tend to snack on non-main meals, diminishing the necessary carbohydrate intake. Thus, ensuring adequate carbohydrate intake in the diets of adolescent girls is vital to support health and physical activity. Fat constitutes a crucial energy source, and studies show that 65% of female students with CED undergo a fat deficit. Even though there is not a significant relationship between fat sufficiency levels and CED, maintaining a balance in fat intake is essential to avert issues of overweight and obesity (Stanek et al., 2022).

Protein is indispensable for body growth and development. Female students with CED face severe protein deficiencies, adversely affecting their health and growth (Nadimin & Asikin, 2025). Adequate protein in the diet of adolescent girls is critical to preventing CED and other health problems. Adolescent girls require sufficient energy intake to support their growth and development. Studies show that 47 female students with CED experience energy deficits, significantly influencing their CED levels (Deshmukh et al., 2006; Petry et al., 2019). Ensuring that adolescent girls have adequate energy intake is crucial to prevent CED and nutrition-related health problems.

Relationship between Family Income Level and CED

Socioeconomic status and family income play a crucial role in societal nutritional status. Poverty and restricted access to food can lead to malnutrition, whereas higher income levels may contribute to childhood obesity (Siddiqui et al., 2020). Adequate adolescent food intake is pivotal to supporting their growth and development, and low food intake heightens the risk of CED (Faris et al., 2023). While family income distribution among young women experiencing CED displays variations, this research finds that family income does not significantly influence CED. This may be attributed to other factors, such as dietary habits, nutritional knowledge, and access to nutritious food, which are well-regulated within Islamic boarding schools. Therefore, preventing nutritional issues and CED in adolescent girls necessitates considering other factors beyond family income.

Relationship between Age Status and CED

Age is not the primary determinant when assessing the nutritional status of children, especially toddlers, children, and adolescents (Wrottesley et al., 2023). Although older adolescents may better understand the significance of nutritional status, bivariate testing indicates a significant relationship between age and Chronic Energy Deficiency (CED) in adolescents. However, multivariate analysis demonstrates that age does not influence CED among female students, indicating a consistent understanding across early and late adolescents. Teenagers generally pay attention to nutritional intake and possess adequate knowledge about nutrition and healthy eating patterns. Young adult students and adults exhibit similar control over food decisions and nutritional requirements, with lifestyle and time constraints minimally influencing their decisions (Ziegler et al., 2021). The importance of Islamic boarding schools as a residence for young women in fostering nutritional knowledge and healthy eating patterns is acknowledged, underscoring their crucial role in character formation and nutritional education for young women of diverse ages. Therefore, efforts must be directed towards increasing the availability and access to healthy food for adolescent girls, especially those unable to fulfill their nutritional needs (Faradila et al., 2020;).

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Relationship between Educational Status and CED

Educational status can impact an individual's health and nutrition, as a lack of information or knowledge about health and nutrition problems can precipitate such issues. Diet is also influenced by education, with higher educational attainment tending to enhance understanding of nutrition and the ability to meet nutritional intake. Nutrition knowledge further affects attitudes and behavior, with formal education often associated with improved eating patterns (Yang et al., 2020). This research indicates that the level of education is connected to CED in young women, where those with higher education face a lower risk of CED (p-value = 0.055). A higher level of education can augment understanding of nutrition and nutritional requirements, influence eating patterns, and reduce the risk of CED. Conversely, young women with lower levels of education may be more susceptible to CED due to a lack of knowledge and awareness regarding the importance of balanced nutrition. Therefore, increasing education and awareness about nutrition among adolescent girls can be crucial in preventing CED and other nutrition-related health problems.

Relationship between Physical Activity and CED

Intense physical activity can augment dietary requirements, especially in young women juggling dual roles as students, rendering them susceptible to malnutrition. This research indicates that a majority of respondents experiencing CED engage in heavy physical activity (81%), significantly correlating with CED (p-value = 0.002), aligning with previous research (Baceviciene & Jankauskiene, 2021). Elevated physical activity levels amplify the body's demand for energy, protein, vitamins, and minerals, including calcium. Calcium is crucial for bone health and muscle function, and during vigorous physical activity, calcium metabolism may undergo alterations, necessitating adequate nutritional intake. High levels of physical activity can also contribute to chronic energy deficiency, especially when food intake is insufficient to meet the energy demands of an active body.

Peer environment with CED

Peers or contemporaries influence young women's knowledge, attitudes, and behavior. They can assist in enhancing the understanding of nutrition and reducing the risk of chronic energy deficiency and anemia in adolescent girls (Khani et al., 2021). However, interactions with peers can also have negative repercussions, particularly if teenagers feel pressured to meet thin and slender body standards to gain acceptance. It is crucial to recognize that the peer environment does not invariably significantly influence nutritional status. Other factors also play a pivotal role in fulfilling the nutritional status of adolescent girls. Nevertheless, education and awareness about balanced nutrition and healthy eating behavior among peers remain essential, and efforts to create a positive and supportive social environment among adolescents can aid in preventing CED and other nutrition-related health problems.

Relationship between Fasting Habits and CED

The everyday fasting habits observed in Islamic boarding schools, especially Monday-Thursday fasting, tend to negatively impact the nutritional intake of female students, with eating patterns confined to 'sahur' (pre-dawn meal) and 'iftar' (breaking the fast). Research establishes a significant relationship between fasting habits and Chronic Energy Deficiency (CED), with most respondents experiencing CED also adhering to fasting habits. This habit can lead to energy imbalance, reduced body fat composition, and nutritional deficiencies without being balanced by understanding and efforts to maintain a well-rounded nutritional intake. Therefore, increasing awareness and education about the importance of maintaining proper nutritional intake during fasting, especially among female students, is necessary to prevent CED and maintain the health of both physically and spiritually active (Faradila et al., 2020).

Relationship between long of stay and CED

Islamic boarding schools are crucial in educating children to become the next generation with noble and intelligent morals. Teenagers residing in Islamic boarding schools' food intake depends on what is provided on-site. Students must pay more attention to food consumption in a communal dormitory environment (Bailey et al., 2020). If they consistently consume high- carbohydrate foods

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such as meatballs and noodles, they risk lacking iron, calcium, vitamin C, and protein. This research indicates that female students who have lived in Islamic boarding schools for more than six months tend to be more at risk of experiencing Chronic Energy Deficiency (CED). Therefore, special attention is warranted to female students' health and food intake in Islamic boarding schools. Efforts should be made to heighten their understanding and awareness of the importance of balanced food intake, alongside monitoring and regulating food menus in Islamic boarding schools to ensure adequate and balanced food intake for female students.

CONCLUSION

This research found that the prevalence of Chronic Energy Deficiency (CED) among female students at the Darul 'Ulum Islamic boarding school reached 52%. Female students who experience CED are, on average, 15 years old with an arm circumference of around 22.5 cm. Their knowledge and attitudes regarding nutrition tend to be poor, and adequate levels of carbohydrates, protein, fat, and energy in their diets could be much better. Most teenagers who experience CED come from families with low income, young age, limited education level, high physical activity, and poor peers.

The environment is often fast, and I have lived for over six months in an Islamic boarding school. This research also reveals a significant relationship between knowledge, attitude, protein adequacy level, carbohydrate adequacy level, energy adequacy level, fat energy adequacy level, age, education, physical activity, fasting, and length of residence with CED. Therefore, CED prevention at the Darul 'Ulum Islamic boarding school can be done by considering these factors. Based on these findings, several suggestions can be given. Female students must increase their understanding of the importance of balanced nutrition and meeting the body's nutritional needs. Islamic boarding schools can also implement more intensive nutrition education programs and ensure the provision of balanced and nutritious food. The Health Service or Community Health Center can develop nutritional education programs for young women in their communities and regularly monitor their nutritional status. Future research can be more in-depth about the psychosocial factors that influence CED in young women, as well as the influence of social media on their eating patterns.

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