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Nutritional Fulfillment and Anemia Status Monitoring through Android Application "E-Monitoring: Nutritional Intake" and Moringa (*Moringa oleifera)* Leaf Premix Cookies Consumption

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Abstract

BACKGROUND: Adolescent is susceptible to nutritional problems that may lead to anemia. Anemia prevention for women is needed at earlier reproductive age to manifest healthy pregnancy, labor, and offspring. It is necessary to create an effective approach for anemia prevention in adolescent girls.

AIM: The focus of this study was to prevent anemia in adolescent girls by improving their nutritional fulfillment rate through moringa leaf cookies provision and/or e-monitoring.

METHODS: This research was conducted on students from two different high schools using a quasi-experimental design with pre- and post-evaluation. Moringa leaf cookies were consumed for a month on both groups. The intervention group was exposed to an e-monitoring application called "E-monitoring: Nutritional Intake" to record the amount and type of food consumed daily and provide information about personal nutrient percentage fulfilled compared to the recommended dietary allowance.

RESULTS: The results show an increase in nutritional intake in the intervention group, which was significantly different from nutritional intake in the control group. Anemia status changes of participants from anemic to non-anemic conditions in both intervention and control groups were 88.89% and 76.92% consecutively (CI 95%). There was a significant increase in nutrient fulfillment for the intervention group.

CONCLUSION: E-monitoring is an important approach for preventing anemia in adolescents by providing them awareness and information regarding their nutritional needs, with moringa leaf cookies as an effective food to increase hemoglobin.

Introduction

The World Health Organization (WHO) stated that anemia prevalence ranges from 40 to 88% globally, while around 29% of reproductive-aged women have anemia [1]. Adolescent girls have been known to be prone to anemia. A study held in North Sumatra involving a total of 300 adolescent girls found that 30% of respondents suffer from anemia. As many as 13% of adolescent girls had mild anemia, 15.3% had moderate anemia, and 1.7% had severe anemia [2]. The previous research showed that iron deficiency was the most common cause of anemia in 14-16 aged participants (86.9%) [3], [4].

The adolescence growth spurt and physiology require them to fulfill an increased number of nutrient needs. For this reason, adolescents are one of the age groups that are vulnerable to anemia. Sociocultural factors (especially education and economics) also play a big role in affecting their diet and nutritional intake. People in this age group tend to be very concerned about their body image, so they often make unreasonable restrictions on food consumption [5], [6], [7]. Women in their productive age who experience anemia will carry such detrimental impacts, including being anemic during pregnancy, increasing the risk of stillbirths, preterm births, small for gestational age, low birth weight babies, and postpartum hemorrhage [8]. Furthermore, babies born with low body weight will most likely experience metabolic growth disorders such as low Intelligence Quotient (IQ) level. Hence, it is necessary to create an effective approach for anemia prevention in adolescent girls [9], [10].

Moringa (*Moringa oleifera*) is a member of the Moringaceae family cultivated throughout tropical and subtropical areas. *M. oleifera* is an edible plant. A wide variety of nutritional and medicinal virtues have been attributed to its roots, bark, leaves, flowers, fruits, and seeds. Phytochemical analyses have shown that its leaves are particularly rich in potassium, calcium, phosphorous, iron, Vitamins A and D, essential amino acids, and known antioxidants such as β-carotene, Vitamin C, and flavonoids [11]. The results of modern scientific research prove that moringa leaves are such a source of plant-based food rich in nutritional

elements, including iron [12], [13], [14]. Moringa leaves are considered an alternative food source to overcome anemia cases in Indonesia [12]. It was shown that giving *M. oleifera* extract to adolescent girls who suffer from anemia and have low body weight in Gowa, South Sulawesi, can increase hemoglobin and serum ferritin levels by 58% and 50% consecutively [15]. Moringa leaves cookies can be made processing its natural form into moringa flour. The purpose of creating moringa leave cookies is to provide a simple and nutritious supplementary food that is more likely accepted to be consumed sustainably by the teenagers. Moreover, the baking process with certain preferred temperature is best to prevent nutritional content loss in food processing [16], [17].

Along with nutritious food provision, nutritional knowledge is an essential factor that can influence dietary behavior [18]. Media-based nutritional education on edutainment technology has been widely applied worldwide. This approach has a huge potential to appeal in Indonesia, which is a country with vast numbers of internet users [18], [19]. Based on the background, this study aimed to increase the awareness of young women in meeting their nutritional needs from their daily food intake using an accessible mobile application and providing iron-rich food as a snack that can be consumed every day to prevent them from anemia.

Methods

This research was a quasi-experimental with the untreated control group design using pre- and post-evaluation. The intervention given to the sample was the use of the "E-monitoring: Nutritional Intake" application that can be accessed through https://asupangizi.com/, and moringa leaf cookies consumption. Our moringa leaf cookies distributed in this research are produced from local ingredients; we use Nutrisurvey to analyze their nutritional contents.

Target respondents were all female high school students in Percut Sei Tuan District, including the entire population that meets the criteria from two different high schools located in Percut Sei Tuan District, which is determined based on the recommendation of the local Education Office.

The total target respondents of 100 people were divided into two groups, namely, the intervention group consisted of 50 people, and the control group consisted of 50 people. Data were collected directly through questionnaires, while food intake (initial) was obtained by "Food Recall" for the control and intervention groups. Furthermore, after the intervention, food intake data were collected using "Food Recall" in the control group and "E-monitoring: Nutritional Intake" in the intervention group. Moringa leaf cookies were provided to the control group and the intervention group for 30 days by giving every 10 days as many as 20 cookies to be consumed in two pieces or 20 g/day. Measurement of hemoglobin levels was carried out before and after the intervention using the "Accu Check Digital test." Data processing and analysis were carried out descriptively as well as univariate and bivariate analysis with T-test.

Moringa leaf premix cookie recipe used in this research, as listed in Table 1 are based on trials-and-errors utilizing local ingredients until we find the expected products:

Table 1: Moringa Leaf Premix Cookies Recipe

No	Ingredients	Scale
1	Wheat flour	50 g
2	Mung beans flour	45 g
3	Moringa leaf flour	5 g
4	Sugar powder	45 g
5	Skimmed milk flour	10 g
6	Egg yolk	0.5 g
7	Margarine	50 g
8	Butter	5 g
9	Salt	1/6 tsp
10	Vanilla extract	1/6 tsp
11	Baking powder	1/6 tsp

Based on the nutritional content analysis result of our moringa leaf premix cookies (full recipe and per piece) using the Nutrisurvey app, the following nutritional value for each energy, protein, fat, carbohydrate, and iron was obtained as listed in Table 2:

Table 2: Moringa Leaf Premix Cookies' Content Analysis

No	Ingredients	Total	Energy	Protein	Fat	Carbs	Iron (Fe)
		g	kcal	g	g	G	mg
1	Wheat flour	50	182	5.2	0.5	38.2	0.6
2	Moringa leaf flour	5	10.25	1.355	0.115	1.91	1.41
3	Mung bean flour	45	145.35	9.9	0.675	25.56	3.375
4	Sugar powder	45	174.1	0	0	45	0
5	Skimmed milk flour	10	36.8	3.6	0.2	5.2	0
6	Egg yolk	1	2.8	0.2	0.2	0	0.1
7	Margarine	50	318	0	36	0	0
8	Butter	5	35.8	0.045	4.05	0.005	0
9	Baking Powder	1	0	0	0	0	0
10	Salt	1	0	0	0	0	0
Nutritional value/recipe (20 chips)		213	905.1	20.3	41.74	115.875	5.485
Nutritional value/piece		10	45.255	1.015	2.087	5.79375	0.27425

This research has been ethically approved by Ethic Commission of Health Research - Health Polytechnic of Ministry of Health of Medan, No. 01.1596/KEPK/POLTEKKES KEMENKES MEDAN 2021. All participants were willing to participate in this research by written informed consents.

Results

Hb level and anemia status

Hemoglobin (Hb) levels of respondents in the control and intervention groups before and after the intervention can be displayed as follows:

Nutritional fulfillment

Nutritional intake data before the intervention were collected using food recall in the control group and the intervention group. As for the final condition (after the intervention), nutritional intake in the control group was still collected using a 24-h food recall manually using a questionnaire, while in the study, it was collected using e-monitoring app for 5 (five) days for the intervention group. The result is shown in Table 4.

Intervention effectivity

Furthermore, to determine the effectiveness of e-monitoring usage for nutritional fulfillment purposes, an analysis was carried out to determine the difference in nutrient intake for each total energy, carbohydrate, protein, fat, and iron before and after the intervention. The analysis result is shown in Table 5.

Discussion

Table 3 shows that the Hb levels of the control group and the intervention group differed significantly before and after the intervention ($p > 0.05$). This result can be seen from the average value of Hb levels in the control and intervention groups, although they showed the same trend. These findings most possibly occur related to Moringa leaf premix cookies consumption for 30 days that can contribute as much as 30 (days) × 1.08 mg Fe (four pieces of Moringa leaf premix cookies) = 32.4 mg Fe. Based on the data in Table 3, changes in the anemia status of participants in the intervention group were 88.89%, while in the control group, the change was 76.92%. Recent studies using animal subjects also stated that Moringa leaf extract effectively increased the number of erythrocytes and hemoglobin levels of anemic rats when administered at a dose of 0.72 grams/head/day. It was suggested the public could further make various products using Moringa leaf, considering its availability and economic value [20]. This has been applied in other recent study using Moringa leaf soup as supplementary food for pregnant women. The results showed that the average Hb of pregnant women before the intervention was 9.813 g/dL. Compared to after being given Moringa leaf soup, it was 11.494 g/dL [21]. It is crucial to determine the best food form that will most likely get accepted by the targeted population. That is the case in choosing Moringa leaf cookies for this research.

Table 3: Anemia status distribution pre- and post-intervention

Period	Group	Anemia Status		Average Hb level (g/dL)	p-value
		Anemia	Normal		
Pre-intervention	Control	13	37	12.62	0.008
	Intervention	9	40	13.19	
Post-intervention	Control	3	47	12.54	0.019
	Intervention	1	49	13.12	

Table 4 shows that in the initial conditions, the nutritional intakes of participants, including energy, carbohydrates, protein, fat, and iron, were remarkably different, with a higher average intake in the control group. Furthermore, after the intervention, nutritional intake in the control group was still collected using a 24-h food recall manually using a questionnaire, while it was collected using the e-monitoring app for 5 days in the intervention group. It shows that respondents' nutritional intakes were significantly improved for all nutrients, including energy, carbohydrates, fat, protein, and iron. Participants from the intervention group found it easier to note the type and amount of food consumed daily and it was a lot more informative. The use of e-monitoring application can motivate young women to increase their daily nutrient intake based on the information about their personal nutritional fulfillment given in the application. Or instead, if the nutritional intake shows excessive fulfillment, users can be aware and reduce their food intake of a specific nutrient. Nutritional intake fulfillment after intervention shows a significant difference with a higher average fulfillment in the intervention group.

Table 4: Nutritional Fulfillment After Intervention

No.	Nutrients	Group	Mean	p-value
1	Energy	Control	80.221	0.003
		Intervention	90.152	
2	Carbohydrate	Control	51.123	0.009
		Intervention	58.029	
3	Protein	Control	78.207	0.001
		Intervention	92.650	
4	Fat	Control	113.394	0.001
		Intervention	79.189	
5	Iron (Fe)	Control	56.591	0.001
		Intervention	95.273	

Food intake assessment in adolescents has been previously performed using several methods such as food records, 24-h food recall, and food frequency questionnaire. These methods are mostly based on the manual recording. The main disadvantage of the 24-h food recall is the information delay and credibility. It is also challenging to apply the previous assessment methods for measuring daily food intake of adolescents. The most important drawback is adolescent resistance to parents' control and being under the physician's monitoring. The introduction of modern technologies enabled new solutions to the nutrient monitoring problem [22].

Table 5 shows that e-monitoring usage has been able to increase young women's awareness to understand and fulfill their nutritional needs. This can be seen from the increase in nutritional intake of participants, which is significantly higher in the intervention group, described as follows: energy = 3.3 times; carbohydrates = 2.9 times; protein = 1.4 times; fat = 0.8 times; iron (Fe) = 51.7 times. It can be concluded that "E-monitoring: Nutritional Intake" can be used to motivate young women to be more aware and able to meet their nutritional needs. This result fits experts' opinions that empowering young women through programs that can be readily accepted by

logic and provide benefits for improving their nutrition will most likely increase their interest in obtaining and applying to the program [23].

Table 5: Average nutritional intake increasement after intervention

Nutrient	Group	Intake increasement	Effectivity (%)	p-value
Energy	Control	181	3.3	0.01
	Intervention	604		
Carbohydrate	Control	23.2	2.9	0.001
	Intervention	67.7		
Protein	Control	4.0	1.4	0.001
	Intervention	5.6		
Fat	Control	8.4	0.8	0.001
	Intervention	6.5		
Fe	Control	1.2	51.7	0.001
	Intervention	62.0		

Conclusions

Anemia is still one of the emerging nutritional problems in developing countries, especially in adolescent girls who are often prone to various nutritional issues. Empowering young women to utilize e-monitoring application and consume moringa leaf cookies minimum 20 g daily can increase their nutrient fulfillment as for energy (3.3 times), carbohydrates (2.9 times), protein (1.4 times), fat (0.8 times), iron (51.7 times), and considered effective in overcoming 88.89% anemia problems. In summary, there are significant increases for nutritional intake fulfillment and hemoglobin levels after the use of the "E-monitoring: Nutritional Intake" application and moringa leaf cookies consumption.

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