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The effect of FeUP (Fe uptake package) box on adherence to iron tablet intake among adolescent girls with anemia

Dinda Puput Purwanti*, Linda Amalia, Afianti Sulastri,

Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia

Corresponding author: *E-mail: dindapuputpurwanti@upi.edu

Abstract

Background: Anemia remains a major health problem among adolescent girls. Although the distribution of iron tablets continues to expand, adherence remains low due to forgetfulness, lack of motivation, and insufficient monitoring. The FeUP (Fe uptake package) Box is an integrated adherence support intervention that combines a pill box, educational and instruction cards, a self monitoring card, and parental involvement to simultaneously address these barriers and improve adherence to iron tablet intake.

Purpose: To analyze the effectiveness of the FeUP box in improving adherence to iron tablet intake among adolescent girls with anemia.

Method: A quasi-experimental study was conducted using a nonequivalent control group with a pretest–posttest design. Participants were selected through purposive sampling from SMPN 29 Bandung, within the Ledeng Community Health Center service area, and SMPN 2 Parongpong, within the Ciwaruga Community Health Center service area. The sample consisted of 52 adolescent girls diagnosed with anemia, divided equally into an intervention group ($n = 26$) and a control group ($n = 26$). Adherence to iron tablet consumption was assessed using the Morisky Medication Adherence Scale-8 (MMAS-8). The intervention group received FeUP Box educational materials for four weeks, while the control group followed the school's standard iron supplementation program without additional education. Data analysis employed the Wilcoxon Signed-Rank Test to examine within-group changes in adherence and the Mann-Whitney U Test to compare adherence outcomes between the intervention and control groups.

Results: Adherence scores in the intervention group increased from 3.57 ± 1.37 (95% CI: 3.01–4.12) to 5.25 ± 1.23 (95% CI: 4.75–5.75) after the intervention, with a significant improvement ($p < 0.001$; $r = 0.692$). In contrast, no significant change was observed in the control group, with adherence scores changing from 3.04 ± 1.46 (95% CI: 2.45–3.63) to 2.86 ± 1.33 (95% CI: 2.32–3.39) ($p = 0.317$; $r = 0.196$). The increase in adherence scores was significantly greater in the intervention group than in the control group ($p < 0.001$; $r = 0.585$). As a supporting objective measure, hemoglobin levels in the intervention group showed an upward trend after the intervention; however, the increase was not statistically significant.

Conclusion: The FeUP box effectively improved adherence to iron tablet intake among adolescent girls with anemia. Integrating the FeUP box into school-based iron supplementation programs may provide a practical strategy to strengthen adherence and support anemia prevention among adolescent girls.

Keywords: Adherence; Adolescent Girls; Anemia; FeUP Box; Iron Tablets.

INTRODUCTION

Anemia remains a common health problem among adolescent girls due to their increased need for iron during growth and menstruation (Cohen & Powers, 2024; Ministry of Health of the Republic of Indonesia, 2023). According to the World Health Organization (WHO) Global Anaemia Estimates 2025, approximately 30.7% of women aged 15-49 years worldwide had anaemia in 2030 (World Health Organization, 2025). In Indonesia, the prevalence of anemia among adolescents aged 15-24 is 32%, with a higher rate among females the proportion of affected females is higher than that of males (27.2% and 20.3%, respectively) (Ministry of Health of the Republic of Indonesia, 2023). According to data from Health Office of West Java Province, the prevalence of anemia among adolescent girls is 41.93%, or approximately 1.7 million cases (Public Relation of West Java Province, 2022). Furthermore, 40% of adolescent girls in Bandung have had anemia since the onset of their first menstrual period (Communication and Information Office of West Java Province, 2025).

Anemia is defined as a condition in which the hemoglobin level in the blood is below normal that is, <12.0 g/dL in women aged ≥12 years which impairs the distribution of oxygen to the body's tissues (World Health Organization, 2011). In adolescents, anemia can be caused by various factors, including inadequate iron intake, dietary habits that inhibit iron absorption, infections, and blood loss due to menstruation (Dhurde, Patel, Locks, & Hibberd, 2024). Anemia can cause fatigue, impaired concentration, and poor academic performance, and can also affect future reproductive health (Weckmann, Kiel, Chenot, & Angelow, 2023).

Several interventions have been implemented to address anemia, namely through food fortification (Rahim, Daud, Ottay, Sau, & Ismail, 2025), health education (Amperatmoko, Apriningsih, Makkiyah, & Wahyuningtyas, 2022) and iron supplementation (Rusmiati, Ama, & Wahyuni, 2025). Among these efforts, the most effective is iron supplementation, which is considered more affordable, significantly increases hemoglobin levels, and is easy to implement on a large scale (Mesalina, Dariani, & Rahmai, 2024).

The iron tablet supplementation program has become the primary strategy for preventing anemia in adolescent girls. Although the distribution coverage of iron tablets was high, reaching 90.6% in 2024 (Nabila,

2026), The consumption adherence rate remains low at 1.4% (Ministry of Health of the Republic of Indonesia, 2023). Various factors, such as forgetting to take the medication, side effects, lack of motivation, and insufficient supervision, are the main causes of low adherence (Damayanti, Kusharisupeni, Adawiyah, & Hymawati, 2025; Utami & Sudaryanto, 2025; Yusufu, Cliffer, Yussuf, Anthony, Mapendo, Abdulla, & Fawzi, 2023).

Various previous studies have developed interventions to improve adherence to iron tablet use among adolescent girls, including WhatsApp-based reminders, peer monitoring, health education, monitoring cards, and pill boxes (Ezliana, Hapisah, Megawati, & Rusmilawaty, 2024; Firdawati, 2023; Nabila, 2024; Paranduk, Duhita, Isir, & Abdullah, 2024; Al Mufarid, Herviana, & Fadli, 2026; Rusmiati et al., 2025; Wahyunita, Rosyadi, & Fakhrani, 2025; Yuliani, Handayani, & Mariana, 2024). The intervention aims to help adolescents remember their iron tablet schedule and improve the consistency of their intake. However, each method still has its limitations. Peer monitoring is difficult to implement consistently outside the school setting (Al Mufarid, 2026), Digital reminders may be ignored by users (Ezliana et al., 2024), Health education focuses more on increasing knowledge rather than developing a habit of taking iron tablets (Firdawati, 2023). Meanwhile, the monitoring card still relies on consistent record-keeping, so it has not yet been effective in improving adherence (Nabila, 2024). Compared to other methods, the pill box serves as both a visual reminder and a tool for organizing the schedule for taking the tablets, thereby helping to reduce instances of forgetting to take iron tablets, promoting consistent intake, and making it easy to carry while on the go (Falah, Lismayanti, Sari, Setiawan, Restiana, Sasyari, & Munirah, 2022; Roy, Ramaiah, & Prabhudev, 2024; Tresnowati, Kusuma, & Sunarti, 2022; Wahyunita et al., 2025). Consequently, research on the effectiveness of using pill boxes among adolescent girls receiving iron tablets particularly in improving adherence to iron tablet intake and hemoglobin levels remains limited.

To address these limitations, this study developed the FeUP (Fe uptake package) Box, an integrated adherence-support intervention that combines a pill box, educational and instruction cards, a self monitoring card, and parental supervision into a single package. The FeUP Box was intentionally designed to

Dinda Puput Purwanti*, Linda Amalia, Afianti Sulastri,

Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia
Corresponding author: *E-mail: dindapuputpurwanti@upi.edu

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directly address the three major barriers to iron tablet adherence identified in previous studies; forgetfulness, inadequate motivation, and insufficient monitoring through complementary components that work synergistically. Unlike previous interventions, which generally focused on only one strategy such as medication reminders, health education, or adherence monitoring, the FeUP Box simultaneously targets multiple determinants of adherence. The pill box serves as a visual reminder to reduce forgetfulness, the educational cards reinforce knowledge regarding anemia and iron supplementation, the monitoring card promotes self-monitoring and treatment accountability, and parental involvement strengthens external supervision and social support. Additionally, the FeUP Box was intentionally designed to be compact, portable, visually engaging, and adolescent-friendly, allowing it to be easily carried, used during school-based supplementation programs, and integrated into adolescents' daily routines. These practical characteristics may enhance intervention acceptability and facilitate long-term adherence compared with stand-alone educational materials or conventional pill containers. Rather than functioning merely as a medication storage device, the FeUP Box provides a multidimensional adherence-support system by integrating behavioral, educational, and family-based strategies into a single intervention. This integrated approach enables the intervention to simultaneously address several barriers to iron tablet adherence that are commonly targeted separately in previous studies.

To our knowledge, this is the first study to develop and evaluate an integrated adherence package that combines reminder, education, self-monitoring, and parental supervision specifically for adolescent girls participating in the national iron supplementation program.

RESEARCH METHOD

This study employed a quasi-experimental design using a nonequivalent control group pretest-posttest approach. Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Health Sciences and Technology, Jenderal Achmad Yani University, Cimahi (Approval No. 067/KEPK/FITKes-Unjani/V/2026). The study was conducted over a 4-week period (28 days) from May to June 2026 at State Junior High School (SMPN) 29

Bandung and State Junior High School (SMPN) 2 Parongpong, West Java, Indonesia. The research was carried out in collaboration with the Ledeng Community Health Center and the Ciwaruga Community Health Center, which oversee the respective school districts. The independent variable was the FeUP (Fe Uptake Package) Box intervention, whereas the dependent variable was adherence to iron tablet supplementation among anemic adolescent girls.

The study population consisted of all adolescent girls with anemia and hemoglobin (Hb) levels <12 g/dL, as defined by the guidelines of WHO (2011). The sample size was determined based on the available population of eligible adolescent girls with anemia identified during school-based Hb screening and the minimum recommendation of 15 participants per group for experimental studies proposed by Fraenkel and Wallen (1990). Because the available population was limited, a priori sample size calculation was not feasible. Therefore, a sensitivity analysis was performed using G*Power version 3.1.9.7 for the Mann-Whitney U test. With 26 participants per group ($N = 52$), $\alpha = 0.05$, and statistical power of 80%, the present study was able to detect a medium to large effect size (Cohen's $d = 0.79$; $r = 0.37$).

Following Hb screening, students who met the inclusion criteria were enrolled using purposive sampling. Allocation was not randomized. Eligible participants were identified according to the order of screening, which followed the existing classroom sequence in each school. To facilitate intervention implementation and minimize contamination between groups, participants from the same classrooms were kept within the same study group rather than being split across intervention and control groups, as students within the same class frequently interacted and could potentially influence each other's adherence behaviors. Consequently, at SMPN 29 Bandung, eligible participants from Classes 8A and 8B ($n = 17$) were assigned to the intervention group, whereas those from Classes 8C and 8D ($n = 17$) were assigned to the control group. Similarly, at SMPN 2 Parongpong, eligible participants from Classes 7A-7D ($n = 9$) were assigned to the intervention group, whereas those from Classes 7E-7F ($n = 9$) were assigned to the control group. Participants from both schools were subsequently pooled, resulting in 26 participants in the intervention group and 26 participants in the control group for statistical analysis.

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Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia
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The research instrument used the Indonesian version of the Morisky Medication Adherence Scale-8 (MMAS-8) questionnaire, adapted from Alhadi (2023). The questionnaire consists of 8 items. Items 1-4, 6, and 7 use the response options "Yes" and "No," with a score of 0 for "Yes" and 1 for "No." For item 5 specifically, the scoring is reversed: "Yes" = 1 and "No" = 0. Item 8 uses a 5-point Likert scale with the following scores: Never = 1.00; Rarely = 0.75; Sometimes = 0.50; Usually = 0.25; and Always = 0.00. The total score is obtained by summing all scores, with a range of 0-8, where a higher score indicates a better level of adherence to iron tablet consumption. Based on the validity test results, all questionnaire items were deemed valid (calculated $r >$ table $r = 0.361$; $p < 0.05$). The reliability test results showed a Cronbach's Alpha value of 0.640, indicating moderate internal consistency. Although this value is below the conventional threshold of 0.70, the instrument has been widely used in previous adherence studies, and this should be considered as a limitation when interpreting the findings.

Baseline characteristics of participants, including age, grade, body mass index (BMI), menstrual duration, frequency of sanitary pad changes, consumption of iron-rich foods, and previous information regarding iron tablets, were collected using a structured questionnaire. Body weight and height were measured using standardized equipment, and Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). Nutritional status was assessed using the WHO AnthroPlus software to generate BMI-for-age Z-scores (BAZ), and participants were classified according to the WHO Growth Reference for children and adolescents aged 5–19 years as thinness (< -2 SD), normal (≥ -2 SD to $\leq +1$ SD), overweight ($> +1$ SD to $\leq +2$ SD), or obesity ($> +2$ SD) (World Health Organization, 2007). In addition, hemoglobin levels were measured using a *FORA 6 point-of-care testing* (POCT) device as an objective indicator to monitor the participants' anemia status and confirm the regularity of iron tablet consumption during the study period.

Data collection was conducted in three stages. Stage 1 (Pretest). Respondents were recruited based on the eligibility criteria. Written informed consent was obtained from the participants' parents or legal guardians before enrolment. Baseline data were collected by measuring hemoglobin levels and

administering the eight-item Morisky Medication Adherence Scale (MMAS-8) to assess adherence to iron tablet supplementation.

Stage 2 (Intervention). Participants in the intervention group received the FeUP (Fe Uptake Package) Box, an integrated adherence-support intervention consisting of four components: (1) a portable pill box for organizing weekly iron tablets; (2) educational and instruction cards containing information on anemia, iron supplementation, and proper tablet consumption; (3) a daily monitoring card for recording tablet intake; and (4) parental supervision through daily verification of tablet consumption. These components were designed to address common barriers to adherence, including forgetfulness, inadequate motivation, and insufficient monitoring, by combining reminders, education, self-monitoring, and family involvement into a single intervention package.

To ensure intervention fidelity, all participants received identical FeUP Box materials, standardized education, and monitoring procedures delivered by the same research team. Before the intervention, participants attended a 30-minute face-to-face educational session covering anemia, iron supplementation, and the correct use of each FeUP Box component. Each participant then received 10 iron tablets stored in the FeUP Box and was instructed to consume them according to the national iron supplementation program (once weekly when not menstruating and once daily during menstruation). After each tablet intake, participants recorded their adherence on the monitoring card, while parents verified consumption by providing a daily signature. The educational and instruction cards remained inside the FeUP Box throughout the four-week intervention to reinforce key messages on anemia prevention, the benefits of iron supplementation, and the correct method of tablet consumption. Participants were instructed to take the tablets between 7:00 p.m. and 9:00 p.m. Western Indonesian Time (WIB) after their evening meal. The intervention was implemented in the participants' homes under parental supervision.

The control group received only the routine school-based iron supplementation program according to existing school procedures and did not receive the FeUP Box, educational session, monitoring card, or parental supervision protocol.

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Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia
Corresponding author: *E-mail: dindapuputpurwanti@upi.edu

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Stage 3 (Posttest). At the end of the four-week intervention, participants in both groups completed the MMAS-8 questionnaire again to reassess adherence to iron tablet supplementation. Hemoglobin levels were subsequently remeasured using the FORA 6 point-of-care testing (POCT) device to evaluate changes following the intervention.

Potential confounding factors, including dietary patterns, menstrual status, participant motivation, and family support, could not be fully controlled. To reduce their potential influence, standardized intervention procedures were implemented, adherence was monitored using daily monitoring cards, and parents were actively involved in supervising tablet consumption throughout the intervention period.

Data were analyzed using IBM SPSS Statistics version 27. Descriptive analysis was used to describe respondent characteristics, the level of adherence to iron tablet consumption, and hemoglobin (Hb) levels using mean, standard deviation, minimum, and maximum values. Normality tests were performed

using the Shapiro-Wilk test. The results of the normality tests showed that the pretest data in the intervention group ($p = 0.030$) and the control group ($p = 0.002$) were not normally distributed, whereas the post-test data in the intervention group ($p = 0.523$) and the control group ($p = 0.107$) were normally distributed. Therefore, bivariate analysis was performed using nonparametric tests. Changes in adherence scores within each group were analyzed using the Wilcoxon Signed-Rank Test, whereas differences in adherence scores between the intervention and control groups were analyzed using the Mann-Whitney U test. Statistical significance was set at $p < 0.05$. In addition to p-values, effect sizes (r) were calculated for all non-parametric analyses using the formula $r = Z/\sqrt{N}$ to quantify the magnitude of the intervention effect. Effect sizes were interpreted according to Cohen (1977), where r values of 0.10, 0.30, and 0.50 represent small, medium, and large effects, respectively.

RESEARCH RESULTS

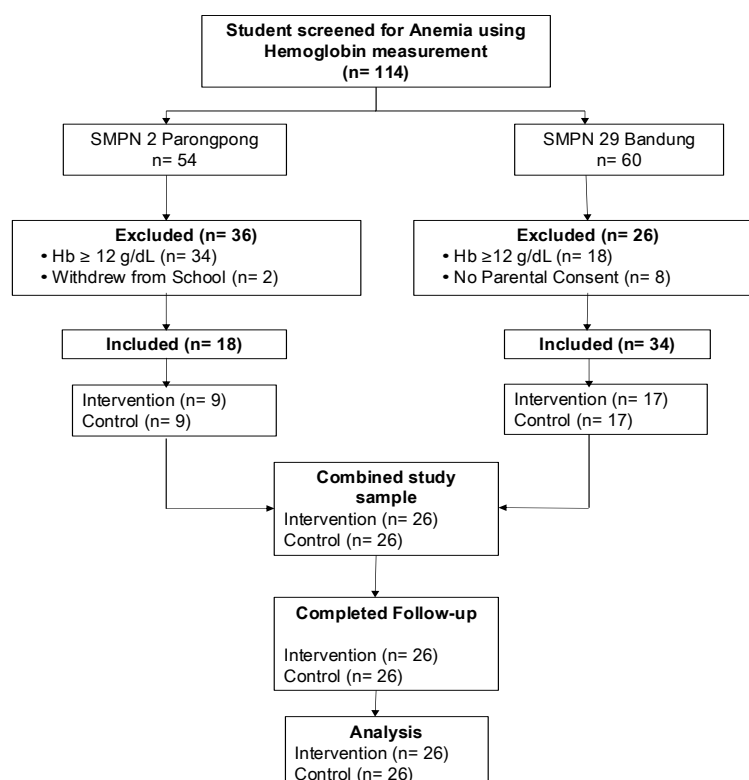


Figure 1. Flow Diagram of Participant Recruitment, Allocation, Follow-Up, and Analysis

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Figure 1. Flow diagram of participant recruitment, eligibility screening, group allocation, follow-up, and final analysis. A total of 114 female students from SMPN 29 Bandung and SMPN 2 Parongpong underwent hemoglobin screening. Eligible participants were enrolled using purposive sampling and assigned to the intervention and control groups according to their existing classroom assignments. Fifty-two participants (26 intervention and 26 control) completed the study and were included in the final analysis.

Table 1. Baseline Characteristics of Participants (N= 52)

Variable	Results		p-value
	Intervention (n= 26)	Control (n= 26)	
Age (Mean±SD) (Range) (Year)	(13.85±0.63) (13-15)	(13.81±0.63) (13-15)	1.000
Age (n/%)			
13	7/26.92	8/30.77	
14	16/61.54	15/57.69	
15	3/11.54	3/11.54	
Grade			0.760
7	7/26.92	8/30.77	
8	19/73.08	18/69.23	
Body Mass Index (n/%)			0.668
Thinness	0/0	1/3.85	
Severe Thinness	0/0	0/0	
Normal	24/92.31	22/84.61	
Overweight	2/7.69	3/11.54	
Obesity	0/0.00	0/0.00	
Menstrual Duration (n/%)			<0.001
<3	0/0.00	3/11.54	
>7	14/53.85	18/69.23	
4-7	12/46.15	5/19.23	
Pad Changes/Day (n/%)			0.704
<2	4/15.38	6/23.08	
>4	3/11.54	4/15.38	
3-4	19/73.08	16/61.54	
Consumption of foods high in iron (n/%)			0.302
<1/week	7/26.92	2/7.69	
1-2/ week	4/15.38	7/26.92	
3-4/week	7/26.92	8/30.77	
Everyday	8/30.78	9/34.62	
Information on Iron Tablets (n/%)			0.780
Yes	14/53.85	15/57.69	
No	12/46.15	11/42.31	

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Table 1 presents the baseline characteristics of participants in the intervention and control groups. The mean age of participants was comparable between the intervention and control groups (13.85 ± 0.63 vs. 13.81 ± 0.63 years), with most participants aged 14 years and enrolled in grade 8. The majority of participants in both groups had a normal body mass index. Most participants reported changing sanitary pads 3–4 times daily, had low to moderate consumption of iron-rich foods, and approximately half had previously received information about iron tablets. Baseline comparisons showed no significant differences between the intervention and control groups in age ($p = 1.000$), class ($p = 0.760$), body mass index ($p = 0.668$), frequency of sanitary pad changes ($p = 0.704$), iron-rich food consumption ($p = 0.302$), or prior information regarding iron tablets ($p = 0.780$). However, menstrual duration differed significantly between the groups ($p < 0.001$).

Table 2. Comparison of Iron Tablet Adherence Scores Before and After the Intervention (N=26)

Group	Pretest	Post-test
	Mean $\pm$ SD (95% CI)	Mean $\pm$ SD (95% CI)
Intervention (FeUP Box)	3.57 ± 1.37 (3.01–4.12)	5.25 ± 1.23 (4.75–5.75)
Control	3.04 ± 1.46 (2.45–3.63)	2.86 ± 1.33 (2.32–3.39)

Table 2 shows that the mean adherence score in the intervention group increased from 3.57 ± 1.37 (95% CI: 3.01–4.12) at baseline to 5.25 ± 1.23 (95% CI: 4.75–5.75) following the intervention, indicating a substantial improvement in adherence. In contrast, the control group demonstrated a slight decline in the mean adherence score, decreasing from 3.04 ± 1.46 (95% CI: 2.45–3.63) at baseline to 2.86 ± 1.33 (95% CI: 2.32–3.39) at post-test.

Table 3. Wilcoxon Signed-Rank Test of Fe Tablet Adherence Scores in Each Group

Group	Z	p-value	Effect size (r)
Intervention (FeUP Box)	-3.529	<0.001	0.692
Control	-1.001	0.317	0.196

Table 3 presents the results of the Wilcoxon Signed-Rank Test comparing pretest and post-test iron tablet adherence scores within each group. The intervention group demonstrated a statistically significant improvement in adherence following the FeUP Box intervention ($Z = -3.529$, $p < 0.001$), with a large effect size ($r = 0.692$). In contrast, no statistically significant change was observed in the control group ($Z = -1.001$, $p = 0.317$), with a small effect size ($r = 0.196$). These findings indicate that the FeUP Box intervention produced a substantial improvement in medication adherence.

Table 4. Mann-Whitney Test for Changes (Δ) in Iron Tablet Adherence Scores

Variable	Group	Mean Rank	Sum of Rank	Mann-Whitney U	Z	p-value	Effect size (r)
Delta Adherence Score	Intervention	35.33	918.50	108.50	-4.220	<0.001	0.585
	Control	17.67	459.50				

Table 4 presents the results of the Mann–Whitney U test comparing changes (Δ) in adherence scores between the intervention and control groups. A statistically significant difference was observed between groups ($U = 108.50$, $Z = -4.220$, $p < 0.001$). Participants in the intervention group showed a substantially greater improvement in adherence than those in the control group, as reflected by a higher mean rank (35.33 vs. 17.67). The effect size was large ($r = 0.585$), indicating that the FeUP Box intervention had a strong impact on improving adherence.

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Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia
Corresponding author: *E-mail: dindapuputpurwanti@upi.edu

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Table 5. Changes in Hemoglobin Levels Before and After the Intervention

Group	Pretest (Mean $\pm$ SD)	Post-test (Mean $\pm$ SD)	Z	p-value
Intervention (FeUP Box)	10.996 $\pm$ 0.827	11.538 $\pm$ 1.454	-1.690	0.091
Control	10.915 $\pm$ 0.741	10.627 $\pm$ 1.129	-1.758	0.079

Table 5. presents the hemoglobin levels before and after the intervention. In the intervention group, the mean hemoglobin level changed from 10.996 $\pm$ 0.827 g/dL at pretest to 11.538 $\pm$ 1.454 g/dL at post-test, while in the control group it changed from 10.915 $\pm$ 0.741 g/dL to 10.627 $\pm$ 1.129 g/dL. However, the Wilcoxon test indicated that these changes were not statistically significant in either the intervention group ($Z = -1.690$, $p = 0.091$) or the control group ($Z = -1.758$, $p = 0.079$). Therefore, the observed changes in hemoglobin levels should be interpreted cautiously. In this study, hemoglobin measurements were included as supporting objective data to complement the interpretation of the primary outcome, while adherence to iron tablet consumption remained the main outcome of the study.

DISCUSSION

The distribution of Fe uptake package (FeUP) box had a significant effect on improving adherence to iron tablet consumption among adolescent girls. Descriptively, the mean adherence score in the intervention group increased significantly. In contrast, there was no significant change in the adherence score in the control group. These findings indicate that the use of the FeUP box is effective in improving adherence to iron tablet intake among adolescent girls.

This increase in adherence is believed to be due to FeUP box combining complementary components: the pill box as a visual reminder and the monitoring card as a tool for tracking consumption, while also involving parents in monitoring iron tablet intake. The pill box helps participants remember their iron tablet schedule, thereby reducing instances of forgetting to take the tablets one of the causes of low adherence among adolescent girls. These results are consistent with a study stating that the use of a pill box makes it easier for users to remember when to take their medication because the medication is neatly organized according to dosage and schedule (Falah et al., 2022). Furthermore, this is supported by a study on patients with diabetes mellitus which stated that pill

boxes help organize medication based on the time of administration. It makes it easier to remember medication schedules and reduces missed doses, making it easier for patients to manage their medication schedules (Safari, Suprapti, Libriansyah, & Bernadus, 2025). These research findings can also be explained by the practical function of the pill box component in the FeUP box. Using a pill box makes it easier for patients to carry their medication while traveling. Although these findings were based on cancer patients, the principle of easy access to medication can also explain the results of this study (Roy et al., 2024). The ease of carrying iron tablets allows adolescent girls to continue taking their tablets on schedule even when they have activities at school or outside the home, thereby helping to reduce missed doses.

Another factor that may have contributed to the improved adherence was the use of the monitoring card, which enabled adolescents to track their iron tablet intake and develop the habit of regularly monitoring their own health behavior. This finding is consistent with a research stating that the use of a medication card helps patients understand their treatment regimen, remember their medication schedule, and serves as a reference when patients forget the therapy they are undergoing (Bumpus, Rogers, & Rust, 2024). In this study, the monitoring card also served as a tool for recording iron tablet intake. These daily records made it easier for teachers and health center staff to monitor and periodically summarize adherence to iron tablet intake. The use of medication cards can improve communication between healthcare providers and patients. The instruction card also serves as an educational tool that provides information on usage, dosage, and the benefits of taking iron tablets. This information helps adolescent girls remember the importance of taking iron tablets regularly. These findings are consistent with a study reported that the use of *pill cards* helped participants remember the benefits of taking medication (Setiani, Nurdin, & Rakasiwi, 2021).

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In this study, the FeUP Box involved parents in monitoring the consumption of iron tablets. This involvement allowed adolescents to receive support and supervision while taking the tablets, thereby strengthening adherence. These findings are consistent with the study which showed that social support and parental participation in the treatment process are positively associated with increased medication adherence in children with epilepsy (Yang, Huang, Tao, Hao, Zhao, & Zhang, 2025). The findings of this study are further supported by the results of a study showing that parental involvement through supervision and support during the treatment process plays a crucial role in improving children's medication adherence (Ge, Liu, Xu, Zhang, Lai, Fu, & Wu, 2022). That study also stated that enhancing parents' capacity to support their children's treatment is an effective strategy for improving adherence.

The consistency of these results indicates that the use of reminder tools combined with monitoring is a practical strategy for improving medication adherence across various age groups and medical conditions. The strength of FeUP box lies not only in the individual components but in the combination of all three, which complement one another. The pill box serves as a visual reminder, the monitoring card reinforces behavior through self-monitoring, while parental involvement provides external reinforcement for adherence. This combination of behavioral change strategies allows participants to receive comprehensive support, thereby increasing the likelihood of maintaining adherence compared to using a single tool alone. The behavioral mechanism underlying the FeUP box can also be explained using the Health Belief Model (HBM) (Becker, 1974), which suggests that health behaviors are influenced by individuals' perceptions of benefits, barriers, self-efficacy, and cues to action. The FeUP box incorporates several of these components by providing a pill box as a visual reminder (cue to action), a monitoring card to encourage self-monitoring and reinforce confidence in maintaining adherence (self-efficacy), and parental involvement to provide external support and motivation. These integrated behavioral strategies may facilitate more consistent iron tablet intake among adolescent girls by reducing forgetfulness and strengthening adherence-related behaviors.

In contrast to the intervention group, no statistically significant change in FeUP box adherence was found in the control group after the observation

period; in fact, the average adherence score in the control group showed a downward trend compared to before the intervention. These findings indicate that without supporting materials, it is difficult to maintain improved adherence. Participants in the control group did not receive the FeUP box. As a result, they were at greater risk of forgetting their tablet intake schedule, so adherence tended not to improve during the study period. These findings are supported by several studies reporting that, in addition to the absence of supporting media, low adherence in the control group may also be influenced by adolescents' tendency to forget their iron tablet intake schedule and the lack of established habits regarding regular iron tablet consumption (Damayanti et al., 2025; Fahrnis, Ekasari, & Ermawati, 2024; Ristanti & Fatimah, 2023).

As supporting objective data, the intervention group showed an upward trend in mean hemoglobin levels after the FeUP box intervention, increasing from 10.99 g/dL at baseline to 11.54 g/dL after four weeks, whereas the control group showed a slight decrease from 10.92 g/dL to 10.63 g/dL. However, these changes were not statistically significant ($p = 0.091$ in the intervention group; $p = 0.079$ in the control group) and should therefore be interpreted with caution. Since hemoglobin level was not the primary outcome of this study, these findings should be considered exploratory and are presented only as supporting objective data alongside the primary outcome of adherence to iron tablet consumption. The absence of a statistically significant improvement in hemoglobin levels may be explained by the relatively short intervention period of four weeks. Previous studies have shown that although oral iron supplementation can begin to increase hemoglobin levels within the first few weeks, a clinically meaningful and statistically significant improvement often requires a longer duration of treatment and consistent adherence. A study reported that oral iron therapy can increase hemoglobin levels starting on day 14 and reach a maximum response by day 28, particularly in individuals with good adherence (Okam, Koch, & Tran, 2017). Similarly, an increase of approximately 2 g/dL is generally expected after 3-4 weeks of effective oral iron therapy, while an increase of 1 g/dL over four weeks may still represent an acceptable physiological response depending on individual conditions (Pantopoulos, 2024).

Dinda Puput Purwanti*, Linda Amalia, Afianti Sulastri,

Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia
Corresponding author: *E-mail: dindapuputpurwanti@upi.edu

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In addition, the effectiveness of iron supplementation is influenced by multiple factors beyond adherence alone. The success of increasing hemoglobin levels following iron supplementation depends not only on adherence to the regimen but is also influenced by baseline hemoglobin levels, health status, nutritional status, and individual biological characteristics (Rakanita, Sinuraya, Alfian, Suradji, Suwantika, Anggun, & Abdulah, 2023). These findings are consistent with a study which showed that the administration of iron tablets for 16 weeks, accompanied by education, was not yet able to significantly increase hemoglobin levels. The researchers explained that low adherence to iron tablet intake was one of the factors affecting the effectiveness of supplementation (Utami, Margawati, Pramono, Julianti, Adespin, & Wulandari, 2022). This indicates that the success of iron supplementation depends not only on the administration of tablets but also on strategies that can improve adherence. In addition to adherence, dietary factors that influence iron absorption may also contribute to the effectiveness of iron supplementation. Adolescent girls with higher consumption of iron absorption enhancers, including heme iron, non-heme iron, vitamin C, and fructose, had a significantly lower prevalence of anemia (Amalia, Yunitasari, & Pragholapati, 2026). This finding suggests that optimal iron status depends not only on consistent iron supplementation but also on dietary practices that enhance iron bioavailability. Therefore, interventions such as the FeUP box may provide greater benefits when combined with nutrition education promoting iron-rich foods and appropriate dietary habits to maximize the effectiveness of iron supplementation. The intervention group in the present study demonstrated an upward trend in mean hemoglobin levels following the FeUP box intervention. However, because this increase was not statistically significant, the finding should be interpreted as an exploratory observation rather than conclusive evidence of clinical effectiveness.

This study has both scientific and practical implications. Scientifically, it contributes to the growing evidence on the use of combined reminder strategies, including a pill box and monitoring card, to improve medication adherence among adolescent girls in school-based iron supplementation programs. Practically, FeUP box represents a simple, user-

friendly, and low-cost intervention that can be integrated into school health programs to support adherence to iron tablet consumption.

This study has several limitations. The four-week intervention period reflects a short-term evaluation, which may limitedly capture the full gradual changes in hemoglobin or the long-term sustainability of adherence. In addition, the relatively small sample size and non-randomized, school-based allocation may have limited generalizability and introduced potential residual confounding and school-level clustering effects despite comparable baseline characteristics. Nevertheless, the available sample size was adequate to evaluate medium-to-large overall intervention effects.

CONCLUSION

FeUP box significantly improved adherence to iron tablet consumption. Although hemoglobin levels tended to increase, the change was not statistically significant after four weeks of intervention. Longer follow-up is needed to evaluate its effect on hemoglobin.

Future studies should employ larger samples determined through a priori power calculations, randomized allocation, and longer follow-up periods to confirm the long-term effectiveness of the FeUP box. In addition, future research should evaluate factors influencing hemoglobin response, including dietary iron intake, adherence to iron supplementation, and other determinants of iron absorption.

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Dinda Puput Purwanti*, Linda Amalia, Afianti Sulastri,

Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia
Corresponding author: *E-mail: dindapuputpurwanti@upi.edu

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Dinda Puput Purwanti*, Linda Amalia, Afianti Sulastri,

Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia
Corresponding author: *E-mail: dindapuputpurwanti@upi.edu

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Dinda Puput Purwanti*, Linda Amalia, Afianti Sulastri,

Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia
Corresponding author: *E-mail: dindapuputpurwanti@upi.edu

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Dinda Puput Purwanti*, Linda Amalia, Afianti Sulastri,

Program Studi Keperawatan, Fakultas Pendidikan Olahraga dan Kesehatan, Universitas Pendidikan Indonesia
Corresponding author: *E-mail: dindapuputpurwanti@upi.edu

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