Effect of digital game-based nutrition education on adolescents' breakfast intake in Bogor: a quasi-experimental study

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Abstract. Breakfast plays a crucial role in adolescents' academic performance and activities, yet breakfast behavioral problems remain common. This study evaluated the effect of the Nutri Quiz digital game-based nutrition education on adolescents' breakfast intake and contribution. A quasi-experimental with pre-post control group design was conducted among students from four senior high schools in Bogor, Indonesia, from September to December 2024. The intervention group received the Nutri Quiz game (IG; n=38), and the control received leaflets (CG; n=38). The intervention duration lasted 4 weeks, with an endline and follow-up conducted one and four weeks post-intervention. Dietary intake was collected using 2x24-hour dietary recalls. Significant difference was observed in both groups at endline ($p<0.05$), in breakfast energy (IG: Δ82±183-kcal, CG: Δ99±183-kcal), carbohydrate (IG: Δ13.1±23.5-gram, CG: Δ15.0±23.1-gram), and protein intake (IG: Δ3.7±9.5-gram, CG: Δ1.9±10.2-gram). The intervention group had significantly higher carbohydrate and fiber intake at endline, and energy, carbohydrate and fiber intake at follow-up than the control group ($p<0.05$). Both groups showed improvements of 15-30% breakfast contribution in energy, carbohydrate, and protein ($p<0.05$). Overall, the Nutri Quiz digital game-based educational intervention showed promise in improving breakfast intake.

1 Introduction

Adolescence is one of the most important periods in human life, as lifestyle choices, such as nutrition-related behaviors, during this period often persist into adulthood and affect nutritional intake and status in the long term [1]. Therefore, unhealthy dietary behaviors may lead to nutritional problems in adolescents. One of the most common behavioral issues among adolescents is poor breakfast behavior.

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Breakfast serves as a primary source of energy and nutrients for adolescents to support their academic and daily activities [2]. Unfortunately, poor breakfast quality and quantity remain prevalent issues. Several studies in Indonesia have indicated that between 39% and 68.2% of adolescents demonstrated inadequate breakfast practices. A study conducted among senior high school (SHS) students found that 55.4% in Bogor Regency did not consume breakfast on a daily basis [3]. A 2014 study in Bogor City revealed that 16.7% of SHS students experienced issues regarding regular breakfast consumption [4].

Digital-based interventions are promising strategies to address adolescents' behavioral problems [5]. Various digital media, including digital games (i.e., video games), can be used for adolescent education, as this population is accustomed to using technology [6, 7]. Therefore, incorporating digital media into nutrition education (NE) can become an effective strategy to deliver engaging content and influencing behavioral change in adolescents. Digital games are popular among adolescents and have been shown to facilitate positive change when used in NE intervention [8]. Therefore, this study evaluated the impact of the Nutri Quiz digital game-based NE intervention on adolescents' breakfast intake and nutrient contribution in Bogor City, Indonesia.

2 Methods

2.1 Study design and setting

This quasi-experimental study employed a pretest–posttest control group design. It was conducted in Bogor, Indonesia from September to December 2024. Four schools were purposively selected: two SHS served as the control group (CG) given printed leaflets, and the other two schools as the intervention group (IG) received the Nutri Quiz digital game.

The intervention duration was four weeks and included three time points of data collection: before the intervention (baseline, BL), one week after the intervention ended (endline, EL), and four weeks after the intervention ended (follow-up, FU). All procedures were approved by the Ethics Committee for Human Subject Research at IPB University (Ref. No: 1301/IT3.KEPMSM-IPB/SK/2024). Prior to participation, written assent and parental consent were obtained.

2.2 Participants

Sample size was calculated using Cohen's formula [9]. After anticipating a 20% dropout rate, a total of 45 subjects were required per group. The inclusion criteria were: 1) adolescents aged 15–17 years; 2) owned an Android smartphone; and 3) had suboptimal breakfast practices that did not align with the Indonesia balanced nutrition guidelines (e.g., irregular breakfast or lacked one or more food types consumed during breakfast). Exclusion criteria included adolescents who were currently undergoing or had recently received an intervention.

Screening was conducted using an online questionnaire assessing their breakfast habit, including breakfast frequency and food types consumed in the past 7 days. A total of 508 students from four public senior high schools were screened; 90 students provided consent to participate. The principal investigator then randomly assigned two schools to the IG and two schools to the CG. Initially, 48 students were allocated to the IG and 42 to the CG. By the end of the study period (follow-up), 14 subjects withdrew. A total of 76 subjects completed the study, with 38 subjects in each group.

2.3 Intervention

Throughout the four-week intervention phase, subjects in both groups were assigned to engage with their respective educational media: Students in the intervention group (IG) played the Nutri Quiz game installed on their smartphones, whereas those in the control group (CG) received leaflets. The main content centered on healthy breakfast practices and balanced nutrition. The first two weeks emphasized theoretical understanding, whereas the final two weeks focused on healthy breakfast practices. For the CG, participants received weekly leaflets covering the same topics addressed in the digital game; these leaflets were developed and distributed by the researcher through the participants' teachers.

The Nutri Quiz game, developed in Indonesian, is an interactive audio-visual quiz-based learning media that provides immediate feedback to promote positive breakfast behaviors in adolescents. The game was developed from February to August 2024, primarily using Game Maker Studio software. It comprised three sections: learning, practice, and quiz sections. The learning section comprised five 1-minute educational videos for each weekly topic (20 videos in total over four weeks). Participants were required to watch these videos before accessing and engaging with the practice and quiz sessions. The practice and quiz sections were designed to assess participants' knowledge of each topic and to encourage behavioral change. Participants in the IG were encouraged to play the game at least once per week for a minimum of 10–15 minutes, supported by periodic promotional reminders via the WhatsApp group.

2.4 Data collection and statistical analysis

The primary data collected included participants' characteristics and their breakfast intake and nutrient contributions. A 2×24-hour dietary recall (covering both weekdays and weekends) was conducted through interviewer-administered interviews to collect detailed information on breakfast consumption. Breakfast energy and nutrient contribution (%) was calculated as breakfast energy and nutrient intake divided by subjects' individual daily requirements, accounting for age, sex, and Body Mass Index (BMI). Univariate analyses comprised descriptive statistics and tests of normality using the Shapiro–Wilk test. For normally distributed data, repeated-measures ANOVA (RMANOVA) and t-tests were used; for non-normally distributed data, the Friedman test, Wilcoxon signed-rank test, and Mann–Whitney U test were applied. All analyses were conducted at a 95% confidence level, with p-values<0.05 considered statistically significant.

3 Results and discussion

The baseline characteristics of participants in both the IG and CG are presented in Table 1. No significant differences between groups were observed for any of the characteristics ($p>0.05$).

Table 1. General subject characteristics.

Subjects characteristics	Intervention (n=38)	Control (n=38)	p-value
	Mean±SD	Mean±SD	
Age (years)	15.9±0.5	15.9±0.8	0.893[a]
Body weight (kg)	54.3±12.8	57.2±14.2	0.292[a]
Body height (cm)	158.4±8.3	158.7±7.7	0.901[b]
Body mass index (BMI)	21.7±5.3	22.6±4.8	0.224[a]
Pocket money (IDR/day)	26,079±17,352	21,368±8,719	0.382[a]
Breakfast frequency[†]			
Rarely (0–3x per week) [†]	10 (26.3%)	16 (42.1%)	0.343[c]

Often (4–6x per week) [†]	21 (55.3%)	16 (42.1%)	
Everyday[†]	7 (18.4%)	6 (15.8%)	

[a]Mann-Whitney U test, [b]Independent t-test, [c]Chi Square test, [†]Numbers and percentage (%)

Table 2 shows the effects of the interventions on breakfast nutrient intake and nutrient contribution. Based on the Friedman test and repeated-measures ANOVA (RMANOVA), significant differences were observed in both groups for breakfast energy, carbohydrate, and protein intake and contribution ($p<0.05$).

Table 2. Changes in breakfast nutrient intake and contribution at baseline, endline, and follow-up.

Variables	**Group**	**Baseline**	**Endline**	**Follow-up**	**p-value[†]**
		Mean±SD	**Mean±SD**	**Mean±SD**	
Breakfast Intake					
Energy (kcal)	CG	253±168	352±210[a]	339±175	0.004[*2)]
	IG	314±141	398±152[a]	449±203	0.001[*2)]
Carbohydrate (g)[**]	CG	27.5±18.8	42.5±26.5[a]	41.0±20.6	0.000[*]
	IG	42.6±21.4	55.7±20.9[a]	62.7±31.7	0.000[*]
Fat (g)	CG	11.1±9.4	14.4±11.1	14.0±11.1	0.664
	IG	11.1±7.0	12.4±9.3	15.8±9.7	0.378
Protein (g)	CG	9.2±6.9	12.4±8.5[b]	11.8±7.2	0.019[*]
	IG	10.4±6.8	14.8±7.9[b]	15.9±9.2	0.034[*]
Fiber (g)	CG	1.2±1.2	1.3±1.3	1.3±1.1	0.264
	IG	1.5±1.5	1.7±1.2	2.7±2.2[c]	0.107
Breakfast Nutrient Contribution (%)					
Energy	CG	13.3±8.8	18.5±11.1[a]	17.9±9.2	0.003[*2)]
	IG	16.8±7.7	21.3±8.1[a]	24.0±10.9	0.001[*2)]
Carbohydrate[**]	CG	10.5±7.0	16.2±9.9[a]	15.8±8.0	0.000[*]
	IG	16.6±8.5	21.8±8.2[a]	24.4±12.6	0.001[*]
Fats	CG	35.1±29.7	45.7±35.8	44.3±34.6	0.664
	IG	35.8±22.6	39.9±29.0	50.5±30.4	0.378
Protein	CG	19.7±15.2	26.3±18.7[b]	25.8±16.6	0.019[*]
	IG	24.5±18.3	34.0±18.9[b]	36.6±22.4	0.034[*]
Fiber	CG	4.1±4.4	4.7±4.5	4.7±3.8	0.264
	IG	5.3±5.0	6.0±4.4	9.3±7.6[c]	0.107

IG= Intervention group (n=38); CG=Control group (n=38); SD=Standard Deviation; [†]Friedman test, [2)]RMANOVA test, [*]p-value<0.05 (significant), [**]Between-group difference at BL (Independent t-test, $p<0.05$), [a]BL vs. EL (Paired t-test, $p<0.05$), [b]BL vs. EL, (Wilcoxon test, $p<0.05$) and [c]EL vs. FU, Wilcoxon ($p<0.05$)

Within-group analyses showed significantly increases in mean energy, carbohydrate, and protein intake in the IG (Δ82±183 kcal, p=0.008; Δ13.1±23.5 g, p=0.001; Δ3.7±9.5 g, p=0.020) and in the CG (Δ99±183 kcal, p=0.002; Δ15.0±23.1 g, p<0.001; 1.9±10.2 g, p=0.012). Breakfast energy, carbohydrate and protein contribution also improved significantly in the IG (Δ4.5±9.6%, p=0.007; Δ5.2±9.1%, p=0.001; Δ9.5±20.7%, p=0.007) and the CG (Δ5.2±9.7%, p=0.002; Δ5.7±8.7%, p<0.001; Δ6.6±15.7%, p=0.007). The relatively higher standard deviations compared to the mean change was likely due to substantial inter-individual variability in dietary changes, where some participants showed marked improvements while others showed little or no change. Between-group analyses showed significant differences in carbohydrate (p=0.009) and fiber intake (p=0.047) in the IG than in the CG at endline, and higher energy (p=0.013), carbohydrate (p=0.001), and fiber intake (p=0.004) at follow-up. Both groups met the recommended 15–30% breakfast contribution for daily energy and carbohydrate intake. The IG had protein contribution above the recommended 15–30% range, but fat contribution in both groups had exceeded the recommended range. At follow-up, only the IG had a significant increase between endline

and follow-up in fiber intake (p=0.038) and contribution (p=0.037), although fiber contribution in both groups remained below recommendations. Overall, the IG demonstrated more sustained improvements through follow-up than the CG.

The results of this study align with previous evidence indicating that digital nutrition education improved adolescents' nutrition behavior [8]. Gamification, which refers to the incorporation of game-based elements into non-game settings, including nutrition education, can enhance adolescents' motivation and support positive behavioral change [10], [11]. In this study, scoring systems, rankings, and performance-based rewards were incorporated to encourage interaction, engagement, and healthy competition in the IG. Weekly school-based activities, including post-tests and competition with rewards, enhance compliance and engagement in the IG.

This study has a limitation in that baseline carbohydrate intake differed between groups, which may have been due to a higher proportion of participants in the control group (CG) who rarely consumed breakfast at baseline compared with those in the intervention group (IG).

4 Conclusions

This study has provided preliminary evidence that the Nutri Quiz digital game may be an effective nutrition education tool for improving adolescents' breakfast intake. Significant within-group improvements were observed in both groups for breakfast energy, carbohydrate, and protein intake and contribution. However, compared with the leaflet group, the digital game group showed greater improvements in carbohydrate and fiber intake and contribution, as well as more sustained effects at follow-up.

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