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ORIGINAL ARTICLE

The Impact of Daily Nut-Based Snacks and Pre-Meal Fruit Intake on Weight of Overweight Female Adolescents in East Java, Indonesia

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ABSTRACT

Background: The rising prevalence of overweight and obesity among adolescents, especially in low- and middle-income countries, highlights the need for effective, culturally adaptable interventions. Fruits consumed before meals and nut-based snacks are associated with enhanced satiety, better metabolic profiles, and improved weight management. However, limited evidence exists on their combined impact in structured communal settings like Islamic boarding schools in East Java, Indonesia.

Methods: A randomized controlled trial was conducted enrolling 100 overweight female adolescents (aged 13-18 years) living in an Islamic boarding schools in Indonesia. Participants were randomly assigned to four groups of control receiving dietary education alone, and three intervention groups (T1, T2, T3) receiving education plus daily mixed nuts (15, 20 and 25 g) and fruit (200-300 g) with low, moderate, or high glycemic index (GI), consumed prior to meals for 28 days. Body weight and dietary intake (energy, fat, carbohydrates, protein, fiber) were assessed at baseline, day 14, and day 28.

Results: All intervention groups showed significant weight reduction over 28 days ($p<0.001$), with the greatest decrease in T3 (high-GI fruit). Energy, fat, carbohydrate, protein, and fiber intakes increased significantly in T1-T3 groups in comparison to the control group ($p<0.001$). Fiber intake increased 2.5 times from baseline, indicating an improved diet quality.

Conclusion: A combined approach using pre-meal fruits of varying GI and nut-based snacks, paired with nutritional education could effectively reduce body weight and improve macronutrient intake in overweight adolescents. This culturally appropriate strategy can be feasible for addressing adolescent obesity in Islamic boarding schools.

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Introduction

Overweight and obesity in adolescents are raising global health issues, notably in low- and middle-income countries. In 2021, 93.1 million children and 80.6 million youth had obesity, with numbers expected to project to double by 2050, especially in Southeast Asia, East Asia, and Oceania (1). In Indonesia, approximately 14.8% of adolescents aged 13-18 years are categorized as overweight (2). Adolescent overweight is caused by multiple factors, including genetics, hormones, and socioecological influences like low physical activity, sedentary behavior, stress, sleep issues, and poor diet (3). Excess intake of ultra-processed, energy-dense foods and sugary drinks, along with low consumption of fruits, vegetables, and micronutrient-rich foods, significantly contributes to adolescent weight gain (4).

A widely endorsed strategy for adolescent weight management is dietary intervention that emphasizes both quantity and quality specifically, lowering energy density while increasing intake of high-fiber, protein-rich, and unsaturated fat-containing foods to enhance satiety and reduce overall energy intake (5). Consuming fruits before meals increase satiety and reduces total energy intake. The consuming of 35 g peanuts before two main meals daily can be a part of an energy-restricted diet (6). Fruits may support weight loss like low-fat diets. Their glycemic index (GI) affects blood glucose, insulin response, satiety, and later food intake. Fruits with lower GI values may lead to better appetite regulation and lower glycemic excursions (7).

Nuts such as almonds, pistachios, walnuts, and peanuts are functional foods rich in unsaturated fats, fiber, protein, antioxidants, and micronutrients like magnesium and vitamin E (6). Despite their energy density, clinical trials and meta-analyses showed that a moderate nut consumption could not lead to weight gain and resulted in weight loss when replacing refined carbohydrates (8). Weight reduction has been demonstrated after an 8-week almond-enriched diet in overweight women (9). Similarly, incorporating mixed nuts into a calorie-restricted diet led to weight loss comparable to that of low-fat diets (10). Nut consumption was shown to be associated with reductions in body mass index (BMI) and waist circumference in adults (11).

The thermogenic and appetite-suppressing effects of nuts can be attributed to their influence on satiety hormones [Peptide YY (PYY), Glucagon-Like Peptide-1 (GLP-1)], energy metabolism, and incomplete mastication (12). The benefits of nuts and their bioactive compounds in improving lipid profiles and reducing inflammation have been described before (13). This gap is especially relevant in structured environments like Islamic boarding schools, where fixed mealtimes, limited physical activity, and communal living may influence nutritional behaviors and intervention outcomes. Therefore, this study aimed to evaluate the effects of consuming nut-based snacks and eating fruits with different glycemic indexes before meals on body weight and dietary intake in overweight female adolescents in Islamic boarding schools. This approach could offer a simple, practical, and culturally appropriate strategy to improve nutrition and support healthy weight management in adolescent populations.

Materials and Methods

This study used a randomized controlled trial (RCT) with a pre-post-test design and a control group to evaluate the intervention's effectiveness. It was conducted over 28 days at Darussalam Gontor Islamic Boarding School in Ngawi Regency, East Java, Indonesia. A minimum sample size of 70 female adolescents was determined based on methodological guidelines for RCTs with pre-post-test and control group designs. The using analysis of covariance (ANCOVA) in repeated measures designs can reduce the required sample size by up to 25%, depending on the baseline follow-up correlation (14). Therefore, a sample size of 70 was deemed adequate for this study. Eligibility was determined based on predefined inclusion and exclusion criteria, as detailed in Figure 1.

Participants were selected using a multistage random sampling technique from eight dormitories and randomly assigned to four groups including three intervention groups and one control group, with equal allocation to maintain internal validity. Each intervention group received dietary education and a food intervention involving snacks and fruits before the main meals, varying in nut amounts (15 g, 20 g, 25 g) and fruit glycemic index (low, medium, high). All participants were fully informed and provided with written consent. The selection and allocation process are shown in Figure 2.

The selection, allocation, follow-up, and analysis procedures were illustrated in Figure 2. Among 695 screened female adolescents, 595 were excluded and thus, 100 participants were enrolled who were eligible to participate in the study. They were randomly assigned to four groups (25 each) of the control group who received dietary education alone. Treatment group 1 (T1) received education, 15 g of mixed nuts, and low-GI fruits before meals; T2 received education, 20g of nuts, and medium-GI fruits; and T3 received education, 25 g of nuts, and high-GI fruits.

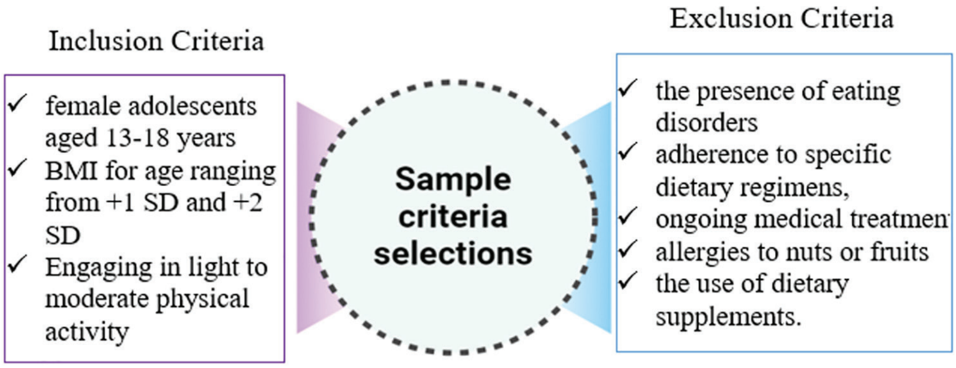

Figure 1: Participants' inclusion and exclusion criteria.

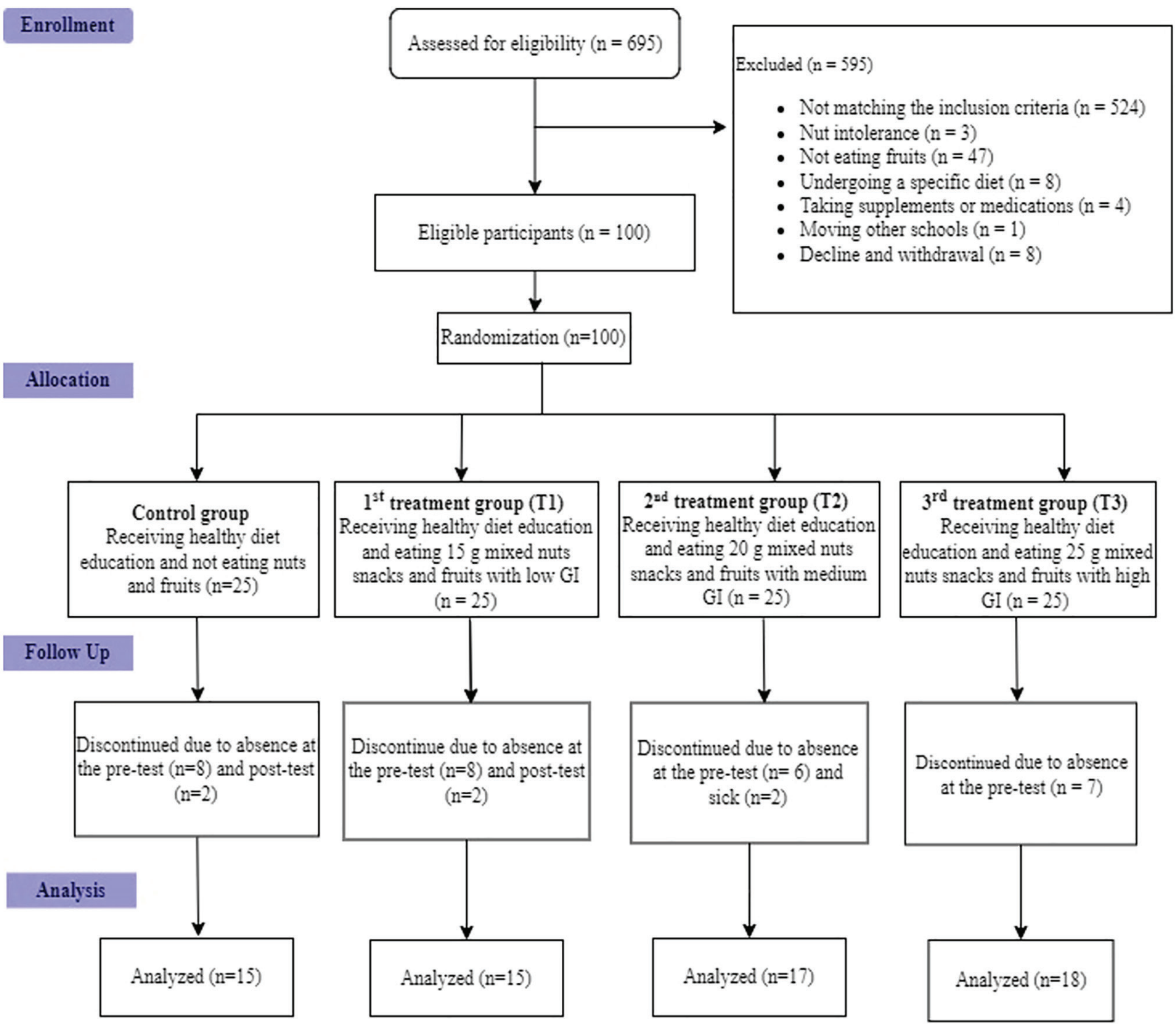

Figure 2: Consort diagram for selection of participants.

Fruit intake followed Indonesia's Balanced Nutrition Guidelines (200–300 g/day). In the control and T1 groups, 8 participants missed the pre-test and 2 missed the post-test, leaving 15 in each group. In T2, 6 missed the pre-test and 1 withdrew, resulting in 17 participants. In T3, 7 missed the pre-test, with 18 completing the study. Only participants who completed both pre- and post-tests were included in the final analysis (n=65) as 15 in the control group, 15 in T1, 17 in T2, and 18 in T3. As illustrated in Figure 3, data collection followed five sequential steps. The 28-day intervention was conducted under supervision in the dormitories of Darussalam Gontor Islamic Boarding School, Indonesia.

All eligible participants were informed in detail about the objectives, procedures, potential risks,

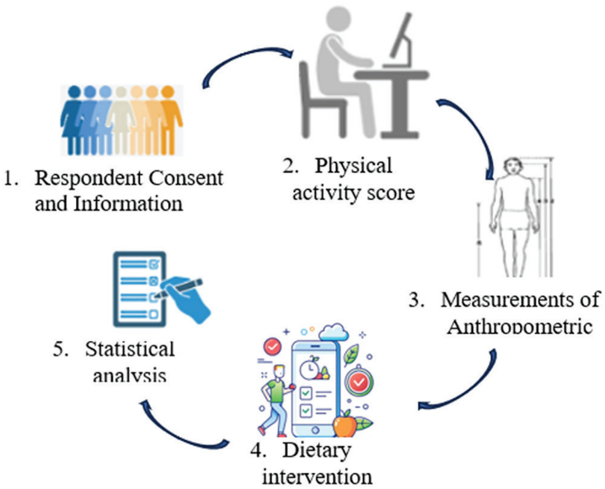

Figure 3: Data collection.

and benefits of the study. Each participant provided written informed consent as a confirmation of their willingness to participate. The research protocol was reviewed and approved by the Research Ethics Committee of the Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia. Ethical clearance was granted under reference number 68/UN27.06.11/KEP/EC/2022, ensuring that the study complied with ethical standards for human subject research. This trial was registered with the WHO International Clinical Trials Registry Platform (ICTRP) under registration number TCTR20250614003 in June 4, 2025.

Physical activity levels were assessed using the Physical Activity Questionnaire for Adolescents (PAQ-A), which had been translated into Bahasa Indonesia and validated for use among Indonesian adolescents. The PAQ-A was consisted of 10 items, each scored on a five-point Likert scale, where a score of 1 indicated the lowest level of physical activity and 5 indicated the highest. The overall physical activity score for each participant was calculated by averaging the scores of all 10 items. Based on the resulting average, physical activity levels were categorized as very low (1.0), low (2.0), moderate (3.0), high (4.0), and very high (5.0). This classification was used to confirm participant eligibility, in accordance with the study's inclusion criteria for light to moderate physical activity levels.

Body weight was measured using a digital scale (OMRON HN-289, precision 0.1 kg) with participants wearing light clothing. Height was measured using a stadiometer (SAGA AU AL-01, accuracy 0.1 cm). BMI-for-age Z-scores were calculated using WHO Anthro Plus software, based on age- and sex-specific growth standards. Weight was assessed on days 1, 14, and 28 to monitor changes during the intervention. Dietary intake was collected via 24-hour recall interviews conducted before, during, and after the intervention.

Data were analyzed using SPSS software (version 25.0, IBM Corp., Armonk, NY, USA). Descriptive statistics presented numerical data as mean±SD and categorical data as frequencies and percentages. Normality was assessed using the Kolmogorov-Smirnov test to determine the appropriate statistical approach. For normally distributed variables and repeated measures, ANOVA was used to evaluate changes in body weight and dietary intake across days 1, 14, and 28, while Bonferroni-adjusted post-hoc tests were applied for significant results. Non-normally distributed variables (e.g., energy and carbohydrate intake) were analyzed using the Friedman test, followed by Wilcoxon signed-rank tests for pairwise comparisons when significant. A p value <0.05 indicated statistical significance.

Results

Baseline comparisons of participant characteristics and dietary intake were conducted to ensure group equivalence. This step was essential to confirm that any outcome differences could be attributed to the intervention rather than pre-existing disparities. Demographic analysis showed comparable mean ages across groups of control (15.67±1.23), T1 (15.53±1.35), T2 (15.53±1.50), and T3 (15.67±1.41) with no significant differences (p=0.994). Physical activity scores ranged from 2.10 to 2.22, and demonstrated no significant variation (p=0.659). Although groups T2 and T3 had slightly higher mean body weights (63.25±6.61 kg and 62.35±4.22 kg, respectively) than the control group (59.21±4.17 kg), the differences were not statistically significant (p=0.110). No significant differences were observed in height (p=0.305) or BMI-for-age Z-scores (p=0.145), supporting baseline anthropometric homogeneity. Average daily energy intake ranged from 1334.29±178.40 to 1388.54±143.32 kcal, with no significant differences across groups (p=0.588). Macronutrient intakes (fat, carbohydrate, protein, fiber) were also comparable, (p=0.900, p=0.864, p=0.883, and p=0. 986, respectively). Detailed baseline data on participant characteristics and dietary intake were presented in Table 1.

This study examined the impact of consuming nuts and fruits with varying glycemic index levels on body weight and macronutrient intake in overweight adolescent girls. At baseline, average body weights in the control (C), T1, T2, and T3 groups were 59.20±4.17 kg, 60.84±5.47 kg, 63.25±6.61 kg, and 62.36±4.77 kg, respectively, with no significant differences between groups (p=0.110). Although body weight decreased across all groups after 14 days, differences remained statistically insignificant (p=0.131).

Table 1: Baseline characteristics of overweight female adolescents.

Variable	C (n=15)	T1 (n=15)	T2 (n=17)	T3 (n=18)	*P* value
	Mean±SD				
Age (Years)	15.67±1.23	15.53±1.35	15.53±1.50	15.67±1.41	0.994[b]
Physical activity (Score)	2.12±0.30	2.22±0.32	2.10±0.21	2.11±0.25	0.659[b]
Body weight (Kg)	59.21±4.17	60.84±5.47	63.25±6.61	62,35±4,22	0,110[a]
Height (cm)	152.34±4.72	153.20±4.17	155.36±6.14	154.68±4.43	0.305[a]
BMI for Age (Z-score)	1.33±0.21	1.44±0.24	1.51±0.25	1.54±0.20	0.145[b]
Energy (Kcal/day)	1334.29±178.40	1403.25±142.87	1377.14±105.82	1388.54±143.32	0.588[a]
Fats (g/day)	23.87±4.67	24.30±9.56	23.60±3.92	23.60±4.91	0.900[b]
Carbohydrates (g/day)	221.92±3.95	221.08±4.65	221.71±5.44	221.91±7.66	0.864[b]
Proteins (g/day)	35.75±4.56	36.87±3.27	36.91±5.93	36,78±4,23	0.883[a]
Fibers (g/day)	6.00±2.15	5.78±2.44	6.13±2.83	6.08±3.5	0.986[a]

[a]Analysis using the one-way ANOVA test; [b]Analysis utilizingg the Kruskal-Wallis test. C: Control group, T: Treatment group.

Table 2: The effects of nut and fruit consumptions on anthropometric data and dietary intake in different groups of female adolescents.

Variable	C (n=15)	T1 (n=15)	T2 (n=17)	T3 (n=18)	*P* value
	Mean±SD				
BW (Kg)					
Baseline	59.20±4.17	60.84±5.47	63.25±6.61	62.36±4.77	0.110[a]
Day 14	59.03±4.25	60.71±5.43	62.92±6.63	62.07±4.70	0.131[a]
Day 28	59.08±4.07	60.20±5.45	62.54±6.70	61.41±4.78	0.199[a]
P value	0.101[f]	<0.001[f]	<0.001[f]	<0.001[f]	
Nutrition Intake					
Energy (g/day)					
Baseline	1334.29±78.40	1403.25±142.87	1377.14±105.82	1388.54±143.32	0.588[a]
Day 14	1517.03±37.30	1629.70±64.47	1716.26±64.84	1665.87±93.38	<0.001[acde]
Day 28	1471.82±127.10	1600.17±95.16	1723.10±112.87	1691.43±135.13	<0.001[acd]
p value	0.005[f]	<0.001[f]	<0.001[f]	<0.001[f]	
Lipid (g/day)					
Baseline	23.87±4.67	24.30±9.56	23.60±3.92	23.60±4.91	0.986[b]
Day 14	28.58±2.12	38.04±2.14	37.73±2.35	35.37±3.73	<0.001[acde]
Day 28	28.54±6.10	34.67±5.85	36.94±4.25	38.92±8.10	<0.001[ac]
P value	0.008 [f]	<0.001[g]	<0.001[f]	<0.001[g]	
Carbohydrates (g/day)					
Baseline	221.92±3.95	221.08±4.65	221.71±5.44	221.91±7.66	0.974[a]
Day 14	227.74±4.38	266.01±7.97	269.65±4.95	272.25±8.50	<0.001[bcd]
Day 28	226.93±7.81	263.49±9.24	264.08±12.49	278.62±30.70	<0.001[bcde]
P value	0.052[g]	<0.001[f]	<0.001[g]	<0.001[g]	
Protein (g/day)					
Baseline	35.75±4.56	36.87±3.27	36.91±5.93	36.77±4.23	0.883[a]
Day 14	42.78±2.33	52.43±3.94	52.77±3.03	51.57±5.54	<0.001[ac]
Day 28	40.86±5.97	51.54±4.27	52.26±5.45	51.93±9.08	<0.001[bc]
P value	<0.001[f]	<0.001[f]	<0.001[g]	<0.001[f]	
Fiber (g/day)					
Baseline	6.00±2.15	5.78±2.44	6.13±2.83	6.08±3.56	0.986[a]
Day 14	7.27±1.26	14.16±1.51	15.72±0.77	14.86±1.14	<0.001[bcde]
Day 28	7.33±2.60	14.17±2.75	16.26±1.03	15.11±1.59	<0.001[bcd]
P value	0.152[g]	<0.001[g]	<0.001[f]	<0.001[f]	

[a]One-Way ANOVA test; [b]Kruskal-Wallis test; [c]Significant differences between the treatment group and the control group; [d]Significant differences were present between T1 and T2 groups, T1 and T3 groups; [e]Significant differences between T2 and T3; [f]Analyzed using the repeated measures ANOVA test; [g]Analyzed using the Friedman test; RDA for adolescents (Energy: 2050-2100 Kcal/day, Protein: 65 g/day, Lipids:70 g/day, carbohydrate: 300 g/day and fiber: 29 g/day). C: Control group, T: Treatment group.

By day 28, the T3 group showed the greatest weight loss (61.41±4.78 kg), followed by T2 and T1, but the between-group difference remained non-significant (p=0.199). However, within-group analysis revealed significant reductions in body weight in all treatment groups (T1, T2, T3) (p<0.001). Energy intake increased significantly in the treatment groups compared to the control. At baseline, average energy intake ranged from 1334.29±78.40 kcal/day (control) to 1403.25±142.87 kcal/day (T1), with no significant group differences (p=0.588). By day 28, energy intake significantly increased in all treatment groups, with T2 illustrating the highest value (1723.10±112.87 kcal/day) (p<0.001). Fat intake also increased significantly, especially in the treatment groups; while T3 reached the highest intake (38.92±8.10 g/day) on day 28. Carbohydrate intake followed a similar trend, with T3 recording the highest level (278.62±30.70 g/day, p<0.001). Protein intake increased in all groups, peaking in T2 (52.26±5.45 g/day on Day 28, p<0.001). Fiber intake showed significant increases only in treatment groups, with T2 reaching 16.26±1.03 g/day by day 28. These findings were presented in Table 2, highlighting significant increases in energy and macronutrient intake particularly in groups T1, T2, and T3 when compared to the control group over the 28-day intervention period.

Figure 4 illustrates the average changes in body weight and intake of energy, fat, carbohydrates, protein, and fiber across all four groups over the 28-day intervention, measured on day 0 (baseline), day 14, and day 28. Body weight declined progressively in all treatment groups (T1, T2 and T3), with the most notable reduction observed in T3, and followed by T2 and T1. In contrast, the control group showed minimal weight change throughout the period. Fat intake increased in all groups, especially in T1 and T2 by day 14, while T3 showed a continued rise until day 28. The control group experienced a modest increase, which plateaued after day 14. A similar trend was observed for carbohydrate intake, with sharp increases in the treatment groups by day 14 and sustained growth in T3 until day 28. The control group showed only a slight rise. Energy intake rose significantly in all groups, with T2 showing the largest increase, followed by T3 and T1. The control group saw a moderate increase on day 14, which remained stable thereafter. Protein intake in the treatment groups increased sharply by day 14 and remained steady until day 28. The control group showed a smaller increase. Fiber intake also rose significantly in T1, T2, and T3, with a notable spike on day 14 followed by slower gains through day 28. The control group exhibited only a minimal increase throughout the intervention.

Discussion

The importance of nutrients in diets has been described before (15) and in this relation, food avoidance has been mentioned to protect health status (16). Based on Table 1, baseline analysis

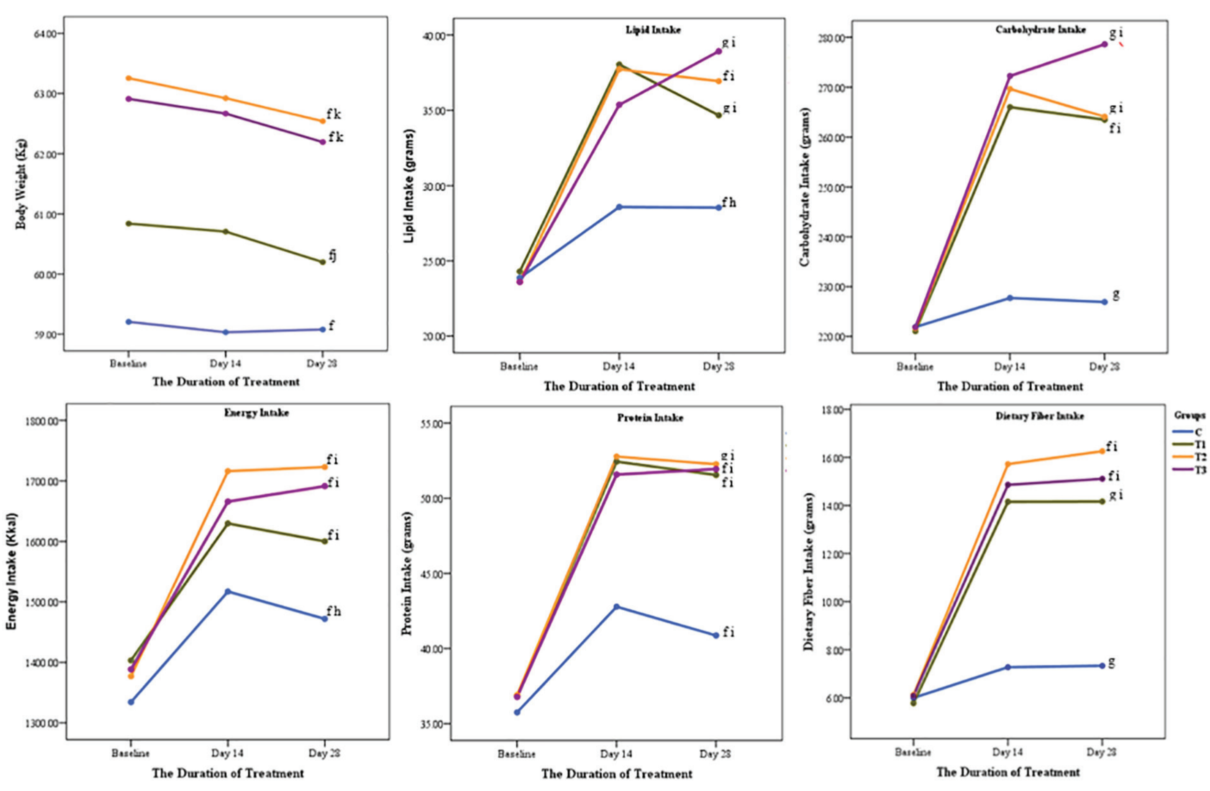

Figure 4: Evaluation of body weight and dietary intake among different groups.

showed no significant differences between groups in age, physical activity, weight, height, BMI-for-age Z-score, and intake of energy, fat, carbohydrates, protein, and fiber. This indicates successful randomization and homogeneity across groups, ensuring that any observed changes during the intervention are attributable to the treatment rather than pre-existing differences. Such comparability strengthens the study's internal validity and aligns with previous findings emphasizing the importance of equalizing baseline characteristics to ensure reliable evidence in nutrition trials (17). Similar conclusions were drawn by Jakubowicz *et al.*, who highlighted that the success of dietary interventions depends heavily on the equality of baseline parameters, particularly BMI and energy intake, to avoid biased outcomes (18). Additionally, the need to account for participants' metabolic backgrounds and lifestyles to minimize confounding effects has been emphasized before (19).

Consistent findings were also reported in previous studies conducted in Islamic boarding schools in Indonesia, such as Gontor Putri (14.4%) (20), Al-Hidayah Sukabumi (15.9%) (21), and Ruhul Islam Aceh Besar (14.4%) (22), which documented similar prevalence for overweight people. The observed low physical activity levels (PAQ-A score 2.0–2.99) are also in line with findings from SMA Wahid Hasyim and Askhabul Kahfi, which reported comparable rates of adolescent overweight (23, 24). Low physical activity (PAQ-A 2–2.99) is also in line with studies at SMA Wahid Hasyim and Askhabul Kahfi which revealed comparable overweight prevalence (23, 24). The low physical activity level (PAQ-A score 2–2.99) observed mirrors findings from SMA Wahid Hasyim and Askhabul Kahfi, where student routines were dominated by academic tasks with limited physical exercise. This context underscores the relevance of food-based interventions as a preventive measure (23, 24).

As presented in Table 2, the 28-day intervention involving the consumption of nuts and fruits with varying glycemic indexes resulted in a significant reduction in body weight within the treatment groups (T1, T2 and T3), with the greatest reduction observed in T3. Although differences between-group were not statistically significant, these results align with previous findings which noted that regular nut consumption supports weight control without increasing obesity risk (25). The intervention also led to significant increases in energy, fat, carbohydrate, protein, and fiber intake, reflecting improved dietary quality (26). In particular, increased fiber intake enhances satiety and helps regulate energy intake (27). The combination of fiber and varying glycemic indexes (low to high) helps regulate glucose and appetite (28).

In addition, the increased intake of protein and healthy fats from nuts is believed to support thermogenic effects and fat metabolism. This effect explains why increased energy intake does not lead to weight gain (29). Associations between nut and fiber intake with weight loss and improved metabolic health over time have been described before (11). Nut and fruit-based interventions are effective in improving nutrient intake and supporting weight control in overweight female adolescents. This effect is in line with studies conducted in San Diego and Los Angeles, which showed that consuming 42.5 g of mixed nuts over 8-12 weeks resulted in a weight loss of 0.9-1.6 kg (30). A study conducted in Adelaide reported a weight loss of up to 6.72 kg after consuming 70 g of nuts daily for six months (31). This finding is also supported by data showing that nut consumption of ≥14.1 g/day reduces the risk of obesity by 16%, and a total weekly nut intake of 198.4 g reduces the risk of being overweight by 3% (32, 33). Although the weight loss was not statistically significant compared to the control group, the results showed a positive trend suggesting that regular consumption of nuts and fruits may yield real physiological benefits over time.

Figure 4 illustrated that the 28-day intervention using healthy snacks; comprising nuts and fruits with varying glycemic indexes (GI); had a notable impact on body weight and macronutrient intake. A steady reduction in body weight was observed across all treatment groups (T1, T2 and T3), with the greatest decrease in T3. This supports the hypothesis that consuming preload snacks before meals can suppress excessive energy intake by enhancing satiety and modulating appetite through hormonal mechanisms, as the benefits of low-energy, high-volume, fiber-rich foods in reducing total daily intake (34).

This is consistent with findings of provious researches revealing that nuts have thermogenic effects and can increase energy expenditure (35, 36). The increased protein and fiber content in the snacks is believed to enhance satiety and thermogenesis (37). In addition, protein and fiber may modulate appetite through hormonal pathways involving peptide YY (PYY) and glucagon-like peptide-1 (GLP-1) (38). The protein and healthy fats found in nuts particularly those rich in unsaturated fatty acids contribute to body weight regulation and improved lipid profiles (6). On the other hand, dietary fibers such as inulin and β-glucan significantly reduce glycemic response (39). The consumption of antioxidant-rich and soluble fiber-rich fruits enhances the body's capacity to regulate inflammation and energy metabolism

(40). The daily intake increased by approximately 274 kcal, 13 g of fat, 44 g of carbohydrates, 6 g of protein, and 9 g of fiber. This is associated with the low bioavailability of fats due to incomplete mastication and increased fecal energy loss (35).

This study revealed that nut and fruit consumption with varying glycemic indexes may improve body weight and nutrient intake in overweight adolescents. For future researches, key improvements include conducting direct lab analysis of snack nutrients, controlling main meals, standardizing physical activity, extending intervention duration, adjusting for baseline weight differences, and expanding study settings beyond Islamic boarding schools. Using objective dietary assessment tools like digital food diaries is also recommended to reduce reporting bias. These strategies will enhance the accuracy, reliability, and generalizability of findings in nutrition interventions targeting adolescent health outcomes.

Conclusion

This study showed that combining daily nut-based snacks with pre-meal fruit consumption of varying glycemic indexes can enhance nutrient intake and support weight reduction in overweight female adolescents. While between-group weight differences were not significant, intragroup analysis revealed meaningful losses, especially in those consuming higher-GI fruits and larger nut portions. The intervention also led to notable improvements in energy and macronutrient intake, indicating both quantitative and qualitative dietary benefits. These results suggest that structured fruit preloads and nut snacks are practical, culturally appropriate strategies for promoting healthy nutrition and weight management in boarding school settings. Future researches should consider longer interventions, including biochemical markers, and monitor physical activity for stronger evidence.

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Authors' Contribution

LP: Conceptualization, methodology, investigation, formal analysis, data curation, writing – original draft, and visualization. DI: Supervision, project administration, writing, review, editing, validation, and methodology. VW: Supervision, writing, review, editing, and validation.

Conflict of Interest

The author declares no conflicts of interest regarding the publication of this article

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