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Behaviour Modification to Improve Profile of Diet Quality and Body Composition of Overweight and Obesity Islamic Students

Modifikasi Perilaku untuk Memperbaiki Profil Kualitas Diet dan Komposisi Tubuh Remaja Santri yang Kelebihan Berat Badan

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ABSTRACT

Background: The prevalence of overweight and obesity in adolescents is significantly high. Overweight and obesity among Islamic students (referred to as *santri* in Indonesian) are caused by low diet quality, characterized by inappropriate food intake and low physical activity (energy expenditure). Behavior modification is needed to improve diet quality and body composition.
Objectives: This study aimed to analyze the effects of a nutrition class on diet quality, body fat percentage, and waist circumference among female Islamic boarding school students.
Methods: This quasi-experimental investigation employed a pre-post test group design with 34 subjects who met the inclusion criteria. The subjects consisted of 17 treatment and 17 control subjects. The treatment group participated in a *santri* nutrition class involving four nutrition education sessions and 12 aerobic exercise sessions in a month. Diet quality data were gathered using the Diet Quality Index-International (DQI-I) form. Body fat percentage was measured using bioelectrical impedance analysis (BIA), and waist circumference was measured using Medline. Data were analyzed using the independent t-test, Mann-Whitney test, Wilcoxon test, and paired t-test.
Results: Subjects with overweight and obesity exhibited low diet quality. Differences in diet quality changes, variation, and adequacy components were observed between the treatment and control groups (p-value=0.001, 0.029, 0.001, respectively). There was no significant differences in changes in body fat percentage and waist circumference between the two groups (p-value=0.487, 0.385, respectively).
Conclusions: The *santri* nutritional class positively impacts diet quality, variation score, adequacy score, and waist circumference among overweight and obese female Islamic boarding school students.

INTRODUCTION

Adolescents are vulnerable to nutritional problems, particularly female Islamic boarding school students (referred to as *santriwati* in Indonesian). Adolescent *santriwati* are at an age of growth and physiological changes, coupled with daily academic and religious activities, making them especially vulnerable to nutritional issues. Currently, there is a double burden of malnutrition among islamic students, including both undernutrition and overnutrition (overweight and obesity). Data from the 2018 Riskesdas indicated that the prevalence of overnutrition among adolescents aged 13-15 years was 15% and 13.5% among those aged 16-18 years[1]. Compared to 2013, this prevalence increased by 4.2% in adolescents aged 13-15 years and by 6.2% in those aged 16-18 years[2]. Research at Amanatul Ummah Islamic Boarding School showed that the percentage of female students with overnutrition was 31.1%, while at Al-Izzah Islamic Boarding School, the percentage of overweight and obesity was 18%[3,4]. Adolescents with higher nutritional status may encounter social and emotional problems, and if this condition continues into adulthood, it will be more challenging to address, posing risks for degenerative diseases such as hypertension, coronary heart disease, diabetes mellitus, atherosclerosis, and respiratory system disorders[5].

Overweight and obesity occur due to a positive energy balance, where energy intake exceeds physical activity used for energy expenditure[6]. Food intake can be assessed through diet quality, which is a score used to compare food intake and is associated with missed meals, nutrient deficiencies, and a high percentage of body or abdominal fat[7,8]. Diet quality can indicate whether food intake aligns with established recommendations[9]. It can be measured using the Diet Quality Index-International (DQI-I), which assesses diet quality from four aspects:

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variation, adequacy, moderation, and overall balance[10]. Low diet quality is often caused by poor eating behavior. Some poor eating habits among students include not consuming fruit daily, snacking more frequently due to less appealing food provided by the boarding school, and consuming fewer protein sources due to limited portions. Research conducted by Garnis and Fillah showed that 96.4% of obese adolescents had low diet quality[11].

Adolescent students rarely engage in sports because, after returning from school, they often participate in additional activities, primarily religious practices. These activities, such as studies, recitation, and dhikr, are predominantly sedentary. Furthermore, the facilities and infrastructure in Islamic boarding schools that support sports activities are limited. Research by Kurdanti et al. demonstrates that obese adolescents have lower level of physical activity compared to their non-obese peers[12]. A study at SMA Negeri 9 Semarang found that adolescents with low physical activity are 7.2 times more at risk of obesity[11]. Research at Darul Hijrah Martapura Islamic Boarding School revealed that 49.8% of female students had low physical activity levels[13].

Overweight and obese adolescent students need to improve their diet quality and physical activity through nutrition education and ithe adoption of a healthy lifestyle, namely by improving their diet and increasing physical activity[14,15]. Adolescence is an opportune time to learn and adopt healthy living habits to prevent future health and nutrition problems[16]. Adolescent students rarely receive information related to nutrition; hence, they require continuous intervention related to diet quality and physical activity. Nutrition interventions are offered through *santri* nutrition classes, which include nutrition education using videos and promoting physical activity.

Nutrition education is provided through videos that present audio and visual information, stimulating both hearing and vision[17]. Videos have an entertaining nature, making it engaging, not monotonous, thus motivating interest in the learning process and resulting in an effective way of learning that remains longer in memory[18]. Research shows that health education through videos (audiovisual) is effective in improving community knowledge, attitudes, and actions[19]. A one-month intervention has been shown to increase knowledge related to healthy weight loss, physical activity, diet quality, and waist circumference reduction in obese female students[20]. Physical activity in nutrition classes includes aerobic exercise, a moderate-intensity activity that releases 5-10 kcal/min of energy. Low-impact aerobic exercise is particularly effective for women aiming to lose weight[21]. Research has demonstrated a positive impact of aerobic exercise on weight loss in adolescents[22].

However, studies focusing on nutritional interventions for adolescent groups, especially overweight female students, through behavioral modifications such as nutrition classes combined with physical activity, are limited. Accordingly, the researchers aimed to investigate how nutrition classes—including nutrition education and aerobic exercise—can influence the diet quality and body composition of overweight and obese female Islamic boarding school students.

METHODS

The research utilized a quasi-experimental design with a pre-test and post-test group format, conducted at the Askhabul Kahfi Islamic Boarding School in Semarang City from December 2020 to January 2021. This study received ethical approval from the Medical/Health Research Bioethics Committee of the Faculty of Medicine at Sultan Agung Islamic University Semarang, under approval number 461/XI/2022/Bioethics Committee, dated November 30, 2022.

The target population of this study was female students of a *pondok pesantren* (Islamic boarding school) in Semarang City. The sample consisted of female students at Askhabul Kahfi Islamic Boarding School, located in Mijen District, Semarang City. The number of samples was calculated using the Federer formula[23], resulting in a minimum number of 16 subjects per group. To anticipate potential drop-outs, the number of subjects per group was increased by 10%, totaling 18 subjects per group. Research subjects were divided into two groups: the treatment group and the control group, requiring a total of 36 subjects. Subjects were selected using consecutive sampling. Initial screening involved 150 female students, and based on age and education level, 49 subjects were selected. Of these, 38 subjects met the inclusion criteria, which included being female Islamic boarding school students (*santriwati*) with at least one year at Askhabul Kahfi Islamic Boarding School, aged 15-18 years, with overweight or obese nutritional status (BMI-for-age >1 SD), low nutritional knowledge (<60%) and willingness to participate by signing an informed consent form. The 38 subjects were then divided into two groups: 19 in the treatment group and 19 in the control group. The division of groups was based on matching nutritional status to ensure equal distribution. Each control group subject was paired with a treatment group subject with the same nutritional status. The treatment group received a nutrition class intervention in the form of nutrition education and aerobic exercise, accompanied by leaflets, while the control group was only provided with leaflets. During the study, four subjects dropped out due to participation rates of less than 80%, missing at least one educational meeting, or two aerobic exercise sessions. These drop-out subjects included two subjects from the treatment group and two from the control group, leaving 17 subjects in each group at the study's conclusion.

The independent variable in this study is the nutrition class program, which includes nutrition education using videos and aerobic exercise sessions. The dependent variables are diet quality, waist circumference, and body fat percentage. The nutrition class program consists of four nutrition education sessions for adolescent students, delivered through videos. These sessions were conducted once a week over a month, with each session lasting 40 to 60 minutes. In addition, the program featured a structured physical activity component consisting of 12 aerobic exercise sessions over the month. These exercise sessions were held three times a week, each lasting 50 minutes. Although energy expenditure during the aerobic exercise was not measured, monitoring was conducted at each session to provide motivation and monitor the heart

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rates of participants, ensuring an appropriate exercise intensity level. The aerobic exercise routines were based on examples from YouTube videos and were demonstrated by the research team. The exercises were designed to be light to moderate in intensity, suitable for individuals with no prior regular exercise habits. Moderate intensity was defined as achieving a heart rate between 64% and 76% of the maximum heart rate (MHR).

Nutrition education was delivered in four progressive sessions, covering the following topics: 1) First Week: Understanding excessive nutritional status, methods for measuring nutritional status, and the causes and consequences of excessive nutritional status. 2) Second Week: Unhealthy behaviors among adolescents and principles for managing obesity and overweight in this demographic. 3) Third Week: Dietary recommendations for those who are obese or overweight. 4) Fourth week: Recommendations for exercise and physical activity, along with the importance of reading food labels. Throughout the education process, researchers closely monitored participants' attendance and engagement during the sessions. Compliance with the nutrition class program was tracked for each subject. Participants who attended fewer than 80% of the sessions (missing more than one nutrition education session or more than two aerobic exercise sessions) were excluded from the study.

Diet quality is a score that compares food intake with established dietary recommendations, reflecting how well a diet aligns with these standards[5]. Food intake data were gathered using the semi-quantitative food frequency questionnaire (SQ-FFQ). Subjects' food intake was measured during two periods: before and after the intervention. Pre-intervention intake was assessed based on the subjects' eating habits over the past month, while post-intervention intake was evaluated based on their eating habits during the one-month intervention period. The average intake during the intervention was then compared to the pre-intervention average using difference analysis. The SQ-FFQ was customized to reflect the types of food commonly consumed by the study participants, allowing for an accurate measurement of their food intake over the past month. The results from the SQ-FFQ were entered into the Nutrisurvey 2007 application to calculate nutrient intake. This information was subsequently assessed for diet quality using DQI-I[5].

The DQI-I was utilized to measure changes in diet quality, which is categorized as low (≤ 60) or high (>60). It evaluates diet quality through four key aspects: 1) Variation: This is assessed by the diversity of food groups (meat, poultry, fish, eggs, dairy, legumes, grains, fruits, vegetables) and the variety of protein sources (meat, poultry, fish, dairy, legumes, eggs). 2) Adequacy: This aspect includes eight subcomponents: vegetables, fruits, grains, fiber, protein, iron, calcium, and vitamin C. 3) Moderation: This encompasses five subcomponents: total fat, saturated fat, cholesterol, sodium, and nutrient-poor foods. 4) Overall Balance: This includes two subcomponents: macronutrient ratio and fatty acid ratio. This approach provides a comprehensive assessment of diet quality before and after the intervention[5].

The evaluation of food variety and protein sources is part of the variation component. The score for the variation category ranges from 0 to 20. The adequacy component assesses the adequacy of eight food groups: fruits, vegetables, fiber-rich foods, staples, iron, protein, vitamin C, and calcium. The score for the adequacy category ranges from 0 to 40, with each food group having a maximum score of 5. The moderation component evaluates foods that require restriction, such as total fat, cholesterol, empty-calorie foods (foods with low nutrient content), and sodium. The score for the moderation category ranges from 0 to 30. The overall balance component assesses the proportion of energy sources and the ratio of saturated fatty acid (SFA), polyunsaturated fatty acid (PUFA), and monounsaturated fatty acid (MUFA). The score for the overall balance category ranges from 0 to 10. The total score from all diet components is divided into two categories: low diet quality (≤60) and high diet quality (>60)[5].

Nutritional status data based on body mass index-for-age (BMI/A) was utilized during the screening process. The BMI data for the subjects were collected using anthropometric methods. Weight was measured with a scale that has a precision of 0.1 kg and a capacity of 180 kg, while height was measured using a OneMed No. 265M microtoise, which has a precision of 0.1 cm and a capacity of 200 cm. The weight (BW) and height (BH) data were then used to calculate BMI, adjusted for age and gender to determine the BMI-for-Age z-score. Subjects classified as overweight or obese (BMI greater than +1 standard deviation or above the 85th percentile[5]) were included in the study.

Waist circumference is a measurement used to estimate the accumulation of abdominal fat. It indicates the presence of fat deposits in the abdomen[24]. In this study, waist circumference was measured using Medline, with <80 considered normal and ≥80 indicating abdominal obesity[25]. Body fat percentage is the percentage of fat mass relative to body weight and was measured using an Omron HBF-214 Body Composition Monitor. Body fat is expressed in percentiles, with obesity defined as >95th percentile, overfat as >85th to 95th percentile, normal as 2nd to 85th percentile, and underfat as <2nd percentile[26].

The collected data included age, nutritional status, diet quality, waist circumference, and body fat percentage of overweight and obese female Islamic boarding school students. Before the intervention study, each group received guidance and briefings regarding the study at different times (not simultaneously). This guidance included rules and technical instructions for implementing the nutrition class program, which consisted of nutrition education and aerobic exercises, along with the schedule for the classes. During the briefing, all participants—both in the treatment and control groups—received leaflets on balanced nutrition for students and dietary management for overweight or obese adolescents. These leaflets were designed in clear and easy-to-understand language and were distributed to the participants without further explanation.

The percentages and diet quality scores between the two groups were analyzed using both the independent t-test and the Mann-Whitney test. Changes in body fat percentage and waist circumference before and after the intervention within each group were

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evaluated using the paired t-test (if the data were normally distributed) or the Wilcoxon test (if the data were not normally distributed). Additionally, differences in the changes (Δ, calculated as post-intervention minus pre-intervention values) in diet quality scores, diet quality components, waist circumference, and body fat percentage between the two groups were examined using the independent t-test (for normally distributed data) or the Mann-Whitney test (for non-normally distributed data). If the test results indicated a p-value of less than 0.05, the null hypothesis was rejected, signifying a significant difference before and after the intervention.

RESULTS AND DISCUSSIONS

Differences in Nutritional Status, Waist Circumference, Body Fat, and Diet Quality Before Intervention

This study was conducted at Askhabul Kahfi Islamic Boarding School, located in Mijen, Semarang City involving 34 overweight and obese female students who were divided into 17 control group subjects and 17 treatment group subjects. Most of the subjects were in grade 11 (61.8%) and were MA students (64.7%) The age range of the subjects was 15-18 years. According to the inclusion criteria, the subjects in this study had a nutritional status based on BMI for age within the overweight/obesity category in both groups. This is indicated by the percentages of overweight (76.5%) and obesity (82.4%). Similarly, the pre-intervention waist circumference of both groups indicated abdominal obesity. However, when measured using body fat percentiles pre-intervention, most subjects in the treatment and control groups (>50%) were in the normal and overfat categories, with only six subjects (35.3%) categorized as obese. In addition, the diet quality of the subjects was in the low category. Diet quality consists of four components: variety, adequacy, moderation, and overall balance. Low diet quality in the subjects is influenced by nutrient intake that does not meet the criteria of diet quality components. The components contributing most to the low quality of the subjects' diet are the lack of variety of protein sources, the insufficient consumption of vegetables, fruits, fiber, calcium, and vitamin C, and the excessive intake of total fat, saturated fat, and nutrient-poor foods.

Table 1. Frequency Distribution of Subject Characteristics Based on Education Level, Nutritional Status, and Diet Quality

Characteristic	Treatment (N=17)		Control (N=17)		Total	
	n	%	n	%	N	%
Class						
10	0	0	2	11.8	2	5.9
11	11	64.7	10	58.8	21	61.8
12	6	35.3	5	29.4	11	32.4
Education						
Islamic Senior High School	14	82.4	8	47.1	22	64.7
Vocational High School	3	17.6	9	52.9	12	35.3
BMI-for-Age (SD)						
Overweight (>+1 SD to +2SD)	13	76.5	14	82.4	27	79.4
Obese (>+2 SD)	4	23.5	3	17.6	7	20.6
Waist Circumference (cm)						
Normal (<80)	1	5.9	4	23.5	5	14.7
Abdominal Obesity (80)	16	94.1	13	76.5	29	85.3
Body Fat (percentile)						
Normal (2^{nd} to 85^{th})	6	35.3	9	44.1	15	44.1
Overfat (>85^{th} to 95^{th})	8	47.1	5	38.2	13	38.2
Obesity (>95^{th})	3	17.6	3	17.6	6	17.7
Diet Quality (score)						
Low (60)	17	100	17	100	34	100
High (>60)	0	0	0	0	0	0

Tables 1 and 2 show that before the intervention, there was no significant difference (p-value>0.05) between waist circumference, body fat percentile, total diet quality score, components and sub-components of diet quality between the treatment and control groups (p-value>0.05). The mean BMI/A was 1.74 SD in the treatment group and 1.57 SD in the control group. Pre-intervention diet quality in the treatment and control groups had a mean of 42.24±4.85 and 43.41±7.33, respectively. The mean body fat percentage in the treatment group was 38.25%±6.67, while in the control group, it was 36%±6.82. The characteristics of the treatment and control subjects before the intervention showed no significant difference (p-value>0.05). This indicates that the subjects of both groups were in similar conditions at the beginning of the study (pre-intervention). Table 1 also shows that the average diet quality in both groups was in the low category, a finding consistent with many other diet quality studies conducted in adolescence, which have also found that most adolescents in Indonesia still have low diet quality[5,9,11].

Low diet quality can be caused by limited dietary variety, inadequate food intake relative to nutritional needs, excessive consumption of foods that should be limited (such as those high in sugar, salt, fat, and cholesterol), and poor overall balance in macronutrients and fatty acids. Several studies on adolescents have shown that low diet quality is marked by insufficient intake of vegetables and fruits, along with excessive consumption of high-energy-density foods, fats, and carbohydrates, particularly sugar[5]. The study

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participants, primarily students with overweight or obese nutritional statuses, displayed low diet quality. This finding is consistent with research indicating that overweight or obese adolescents tend to have lower diet quality compared to those with normal BMI. Diet quality is assessed based on food consumption relative to dietary recommendations or nutrition guidelines established for Indonesians, which are visually represented in the Balanced Nutrition Pyramid (*Tumpeng Gizi Seimbang* or TGS in Indonesian)[5,9].

Table 2. Differences in BMI, Waist Circumference, Body Fat Percentile, and Diet Quality of Subjects before Intervention

Characteristic	Mean±SD		p-value
	Treatment	Control	
Age (years)	16.88±0.92	16.82±0.8	
BMI/A (z-score)	1.74±0.39	1.57±0.5	0.163[b]
Waist Circumference (cm)	88.44±6.71	87.35±9.32	0.699[a]
Body Fat (%)	38.8±5.59	36.62±5.84	0.248[b]
Pre-Intervention Diet Quality (score)	42.24±4.85	43.41±7.33	0.716[b]
Variation (score)	10.5±1.32	11±1.76	0.391[b]
Food Group (type/day)	9.18±0.73	9.53±1.17	0.294[b]
Source of Protein (type/day)	1.35±0.79	1.47±0.87	0.676[b]
Adequacy (score)	17.2±3.17	18±5.09	0.986[b]
Vegetable (servings/day)	2.12±0.48	2.29±1.57	0.067[b]
Fruits (servings/day)	1.1±0.52	1.35±0.78	0.074[b]
Staple Food (servings/day)	4.18±1.01	3.59±1.37	0.208[b]
Fiber (g/day)	10.2±4.63	11±8.76	0.904[b]
Protein (% total energy/day)	14±3.5	15±9.29	0.744[b]
Iron (% RDA/day)	87±68.4	67±36.8	0.326[b]
Calcium (% RDA/day)	32.4±19.2	28.1±12.1	0.757[b]
Vitamin C (% RDA/day)	43.2±41.2	49.2±30.6	0.221[b]
Moderation (score)	13.6±2.62	13.6±2.39	0.951[b]
Total Fat (% total energy/day)	35.7±7.68	42.18±29.7	0.986[b]
Saturated Fat (% total energy/day)	13.7±3.9	17.3±7.01	0.055[b]
Cholesterol (mg/day)	100.9±65.2	74.7±42.3	0.209[b]
Sodium (mg/day)	972.8±562	944.7±286	0.090[a]
Foods Low in Nutrients (% total energy/day)	24.7±13.5	30.12±24.82	0.558[b]
Balance (score)	0.94±1.6	0.82±1.42	0.914[b]
Macronutrient Ratio	0.82±1.59	0.71±1.21	0.894[b]
Fatty Acid Ratio	0.12±0.48	0.12±0.48	1[b]

[a]) Independent t-test, [b]) Mann-Whitney, *) significantly different (p-value<0.05), BMI/A=Body Mass Index/Age, RDA=Recommended Dietary Allowance or *AKG=Angka Kecukupan Gizi* in Indonesian

According to Table 2, the average scores for diet quality components indicate that the variation scores for both groups are low. Ideally, the variation component should have a maximum value of 20; however, both groups only achieved half of that maximum. This suggests a very limited overall variation in food groups and protein sources. The SQ-FFQ results reveal that the diversity of food groups—staples, animal protein, plant protein, vegetables, and fruits—was not met daily. Almost all of the students consumed only two to three types of food, predominantly staples and plant-based proteins, often neglecting vegetables. Animal protein and fruits were very rarely consumed, except on visiting day (or *hari sambangan* in Indonesian) when families brought food during visits.

Additionally, the adequacy component scored below the ideal maximum value of 40. The SQ-FFQ results indicate that the intake of vegetables, fruits, proteins, and several micronutrients such as iron, folate, calcium, and vitamin C falls short of the recommended levels. The moderation component averaged a score lower than the maximum value of 30. Snacking habits significantly impacted the SQ-FFQ results, revealing that the total percentage of total fat, saturated fat, and empty calorie foods exceeded the recommended intake. Total fat consumption accounted for over 30% of total energy, while saturated fat and empty-calorie foods made up more than 10% of total energy. Finally, the overall balance component also registered an average score lower than its maximum value of 10. The SQ-FFQ results indicate that the macronutrient ratio (carbohydrates: fat: protein) for most subjects in both groups scored 0, suggesting that carbohydrates and fats exceeded protein intake, falling below the acceptable macronutrient distribution ranges (AMDR). Additionally, the ratio of fatty acids (PUFA: SFA and MUFA: SFA) displayed very low values (less than 0.8), indicating relatively high saturated fat consumption, resulting in a very small ratio.

Differences in Changes in Diet Quality Composition between Treatment and Control Groups

Table 3 demonstrates that the changes (Δ) in diet quality scores, variation scores, food group adequacy, fruit, fiber, and vitamin C significantly differ (p<0.05) between the treatment and control groups. Most of the mean deltas (Δ) in the treatment group were higher than those in the control group. In contrast, changes in the variation of protein sources, vegetable adequacy, staple food intake, protein, iron, calcium, and all moderation components, as well as overall balance components, did

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not show significant differences between the two groups. Although these changes were not statistically significant, they suggest that the deltas for adequacy and variation components in the treatment group were greater, while the deltas for moderation and overall balance components were lower compared to the control group. This indicates that the treatment group experienced a greater improvement in diet quality than the control group.

Table 3. Differences in Changes in Diet Quality Composition between Treatment and Control Groups

Variable (Δ)	Mean±SD		p-value
	Treatment	Control	
Diet Quality Score	5.82±6.73	-6.29±7.51	0.001[a]*
Variation Score	2.29±2.41	0.24±2.84	0.029 [b]*
Food Group (type/day)	2.29±1.68	0.35±1.8	0.009 [b]*
Protein Source (type/day)	0±1.22	-0.12±1.31	0.812 [b]
Adequacy Score	3.35±4.78	-3.24±5.97	0.001 [a]*
Vegetables (servings/day)	0.06±1.14	-0.59±1.97	0.413 [b]
Fruit (servings/day)	3.29±0.98	0.18±1.01	0.001 [b]*
Staple Food (servings/day)	7.29±1.72	6.29±2.23	0.106 [b]
Fiber (g/day)	2.23±6.26	-3.49±9.3	0.008 [b]*
Protein (% total energy/day)	-3.87±4.33	-3.34±9.62	0.274 [b]
Iron (% RDA/day)	-26.23±87.7	-20.8±46.55	0.824 [a]
Calcium (% RDA/day)	-10.6±20.7	-6.076±14.98	0.472 [a]
Vitamin C (% RDA/day)	132.4±101.7	-18.75±40.5	0.001 [b]*
Moderation Score	0.53±3.71	-0.35±3.65	0.540 [b]
Total Fat (% total energy/day)	-2.88±10	-6.18±30.1	0.413 [b]
Saturated Fat (% total energy/day)	-0.18±4.36	-2±7.68	0.786 [b]
Cholesterol (mg/day)	-55.27±59.07	191.9±705	0.431 [a]
Sodium (mg/day)	-250.7±758.3	-40.73±46.33	0.087 [a]
Nutrient-Poor Foods (% total energy/day)	-7.35±11.6	-14.8±27.06	0.634 [b]
Overall Balance Score	-0.35±1.90	-0.82±1.42	0.518 [b]
Macronutrient Ratio	-0.24±1.85	-0.71±1.21	0.394[b]
Fatty Acid Ratio	-0.12±0.48	-0.12±0.48	1[b]

[a]) Independent t-test, [b]) Mann-Whitney, *) significantly different (p-value<0.05), BMI/A=Body Mass Index/Age, RDA=Recommended Dietary Allowance or *AKG=Angka Kecukupan Gizi* in Indonesian

The results of the t-test showed significant differences in the delta (Δ) scores of diet quality, variety scores, food groups, adequacy, fruit, fiber and vitamin C between the treatment and control groups. This indicates that the *santri* nutrition class through videos effectively improved diet quality scores and some of its components. This is attributed to the advantages of audiovisual media, which are engaging and effective for learning[27]. The difference in delta (Δ) diet quality scores between the treatment and control groups occurred due to an increase in the mean Δ diet quality in the treatment group, the mean Δ variation score and adequacy. The change (Δ) in variation score showed a difference between the two groups, primarily due to an increase in the variety of foods in the treatment group, particularly fruit. Before the intervention, adolescent students rarely consumed fruit. During the study, the students in the treatment group began to increase their fruit consumption. This aligns with Rike's research, which found that nutrition education using audiovisual media can increase fruit intake in adolescents[28]. However, there was no difference in the variety of protein sources, as students consumed animal protein sources only one or two times a week. The source of animal protein for the students was primarily provided by the boarding school only once a week, plus snacks or food brought by parents during visits.

Post intervention, there were differences in adequacy scores between the treatment and control groups, specifically in the fruit, fiber and vitamin C sub-components. This was because the treatment group consumed more fruit than the control group. Fruits are a good sources of vitamins and fiber. The types of fruit consumed by the students included oranges, bananas, guavas and salak. Oranges and guavas are rich in vitamin C, containing 49 mg and 87 mg per 100g BDD (edible weight), respectively. In terms of fiber content, guava and banana contain 2.4g and 5.3 g per 100g BDD, respectively[29]. Research on junior high school students in Denpasar showed a significant relationship between nutritional knowledge and fruit consumption behavior[30]. Before the intervention, the students' vegetable consumption was categorized as insufficient. Based on interviews, some students always consume vegetables, but only in small amounts; others did not like vegetables or were bored with the types of vegetables served. Research shows that individuals with a low frequency of vegetable consumption is three times more at risk of overweight than those with a good frequency of vegetable consumption[31].

The moderation category and its sub-components (total fat, saturated fat, cholesterol, sodium, and nutrient-poor foods) showed no difference between the two groups. Sodium and cholesterol intake in both groups before and after the intervention was within the acceptable range. However, the intake of total fat and saturated fat was excessive in adolescent female Islamic boarding school students due to high consumption of

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fried foods, which are typically high in fat. This finding aligns with research in Iran, which shows that adolescent fat intake tends to be high[32]. Additionally, the intake of low-nutrient food among overweight and obese students was excessive, driven by the consumption of high-energy, low-nutrient snacks. The low change in moderation score leads to an increase in the value of energy intake, especially since fat has an energy density of 9 kcal/g compared to fiber, which only has 1-1,5 kcal/g[9].

The balance scores, which included macronutrient ratios (carbohydrates: fats: protein) and fatty acid ratios (PUFA: MUFA: SFA), showed no differences between the two groups. Overall, balance scores were low both before and after the intervention. Excessive fat intake in both groups (over 30% of total daily energy) affected the proportions of carbohydrates and protein, leading to imbalances in macronutrient ratios. Fatty acid ratios were also low before and after the intervention, primarily due to a higher intake of saturated fatty acids (SFA), which exceeded 10% of total daily energy, compared to polyunsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA) in both the intervention and control groups. These findings are consistent with several studies on diet quality among similar adolescent populations. These studies revealed that adolescents have undergone lifestyle changes, particularly in food choices, which are now often driven by socialization rather than nutritional content. A high intake of total fat, saturated fat, and sugar, coupled with low consumption of fiber from fruits and vegetables, poses a significant risk for developing metabolic diseases at an earlier age, such as diabetes mellitus and cardiovascular diseases[5].

Differences in Body Fat and Waist Circumference before and after Intervention between Treatment and Control Groups

There was no significant difference in the mean percent body fat before and after the intervention in the treatment and control groups (p-value=0.813; p-value=0.225, respectively). For the waist circumference variable, there was a significant difference in the mean waist circumference before and after the intervention in the treatment and control groups (p-value=0.001; p-value=0.038, respectively). However, there was no significant difference in the changes (Δ) in body fat percentage and waist circumference between the control and treatment groups (p-value>0.05).

Table 4. Differences in Body Fat and Waist Circumference between Two Groups before and after Intervention

Variable	Mean+SD					
	Treatment		p-value	Control		p-value
	Pre	Post		Pre	Post	
Body Fat Percentage	38.8±5.59	38.82±6.7	0.813[d]	36.62±5.84	37±5.47	0.255[d]
Waist Circumference (cm)	88.44±6.71	85.41±7.52	**0.001**[c*]	87.35±9.32	85.35±9.8	**0.038**[c*]
Δ Body Fat Percentage	0.02±1.65			0.41±1.6		0.487[a]
Δ Waist Circumference (cm)	-3.02±3.15			-2±3.64		0.385[a]

[a]) Independent t-test, [b]) Mann-Whitney, [c]) Paired t-test, [d]) Wilcoxon, *) significantly different (p-value<0.05)

The percentage of body fat before and after the intervention, and the changes (Δ) in body fat percentage between the two groups did not show significant differences. Despite the intervention group receiving education on balanced nutrition, their fat intake remained high due to the availability of snack foods sold at the boarding school, including many fried foods and energy-dense snacks such as chips. Despite aerobic exercise being offered to the treatment group, it did not result in a reduction in body fat percentage, likely because the aerobic sessions lasted only one month. A longer duration of intervention is necessary. This finding aligns with studies by Galih et al. and Rizka et al. which indicated that low-impact aerobic exercise can effectively reduce body fat percentage when conducted for two months[33,34].

Previous research shows that moderate to high-intensity aerobic exercise can reduce visceral adipose tissue[40]. A 2020 study found that obese women aged 18 to 23 who engaged in aerobic exercise for 12 weeks significantly decreased their total body fat mass[35]. Another study demonstrated that aerobic exercise lasting at least 45 minutes could lead to an 8% reduction in visceral adipose tissue mass[41]. One limitation of this study was the absence of personalized measurement tools to estimate energy expenditure and fat burning for each participant after aerobic exercise during the intervention. Monitoring was limited to heart rate to assess exercise intensity, subject attendance, movement activity, and enthusiasm. Specialized tools, such as Polar devices, are required to ensure participants perform aerobic exercise with the necessary energy expenditure.

Differences in waist circumference were observed among students in both the treatment and control groups before and after the intervention. The treatment group exhibited a greater mean reduction in waist circumference compared to the control group. This reduction in waist circumference in the treatment group students may be attributed to increased motivation for physical activity and healthier food choices. This finding aligns with the study by Sulistyoningrum, which demonstrated that aerobic exercise significantly reduces waist circumference[35]. The exercise intensity was designed to range from light to moderate for individuals who had not previously engaged in regular physical activity. Moderate intensity was defined as reaching 64-76% of the maximum heart rate (MHR). Although the exercise intensity was controlled, the researchers could not ensure that all subjects achieved the same level of moderate intensity by the end of the sessions. This limitation arose because none of the subjects in the intervention group had a habit of regular exercise prior to the study. Previous research has shown that moderate to high-intensity exercise is effective in reducing waist circumference[42]. Aerobic exercise can decrease visceral fat due to the lipolytic effects of catecholamines released

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during exercise, which promote greater utilization of abdominal fatty acids as an energy source[43].

The study results indicated changes in waist circumference (WC) within the control group. This could be attributed to the nutritional information provided in the leaflet that was distributed at the beginning of the study, which included participants from the control group. Those in the control group who received and read the nutrition and weight management leaflet may have felt motivated to lose weight. Lawrence Green's theory suggests that an individual's knowledge and attitudes can significantly influence their habits. Additionally, changes in behavior can occur due to several factors: predisposing factors, enabling factors, and reinforcing factors. Predisposing factors include knowledge and attitudes, with attitude being a behavioral determinant linked to perception, personality, and motivation[45]. In this study, the nutritional information provided in the leaflet to all groups, including the control group, could be seen as a predisposing factor that encouraged behavior change. However, it is important to note that the reduction in waist circumference observed in the control group was still less significant than that seen in the treatment group.

The study results indicated a significant improvement in diet quality scores and several components of diet quality in the treatment group following the intervention. This suggests that nutrition education through videos and aerobic exercise via YouTube can effectively enhance diet quality. Videos, as an educational tool, provide engaging audio-visual information that stimulates both visual and auditory senses.[16] Research has shown that videos are more dynamic and less monotonous, which can increase students' motivation to learn and have a longer-lasting impact on memory[36]. Additionally, other studies have demonstrated that video-based health education is effective in improving community knowledge, attitudes and actions[37]. These changes are interrelated; once individuals acquire information, they assess and respond to it, eventually adjusting their behavior accordingly[38]. Therefore, subjects are encouraged to adopt healthier eating habits, such as consuming a balanced diet,reducing the intake of fried foods and snacks, and increasing their consumption of fruits and vegetables along with engaging in regular physical activity. Future research should incorporate behavior modification that involve education and aerobic exercise while engaging boarding school administrators to control food availability. This would help support students' eating behavior changes and improve the effectiveness of the intervention.

The strengths of this study are evident in its robust design. It employed a two-group, unpaired experimental approach conducted over a specific time period (cohort study). Furthermore, the instruments used in the study not only quantitatively measured changes in food intake (adequacy) but also assessed diet quality through various components, including variety, moderation, and balance. However, the study faced several limitations. It was conducted during the COVID-19 pandemic under government-imposed Large-Scale Social Restrictions (*Pembatasan Sosial Berskala Besar or PSBB* in Indonesian), which restricted the researchers' ability to meet with the students as scheduled. Additionally, the boarding school's policies prohibited the use of electronic communication devices, requiring all data collection to be carried out in person. The researchers had to adhere to strict health protocols, including wearing full personal protective equipment, testing negative for COVID-19 through swab tests, maintaining physical distance, wearing masks, and practicing hand hygiene. Another limitation was the lack of equipment to monitor the exercise intensity of each subject during aerobic sessions. Researchers had to rely on heart rate estimates, calculated using the formula for maximum heart rate (220 minus the subject's age) to gauge exercise intensity[44].

CONCLUSIONS

The nutrition class program, which combined nutrition education and aerobic exercise, proved effective in promoting behavior modification that improved diet quality, particularly in terms of variety and adequacy among female Islamic boarding school students. Furthermore, the treatment group showed a more significant reduction in waist circumference compared to the control group after participating in the program.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

ISF: Writing-original draft, methodology, editing, formal analysis, data curation. FFD: Conceptualization, investigation, methodology, writing-review and editing, research leadership, formal analysis, validation, funding acquisition. AN: Review, investigation, validation. ERN: Review, investigation.

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