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Extra Virgin Olive Oil Supplementation Reduces Anthropometric Risk Factors for Type 2 Diabetes in Adolescent Girls

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ABSTRACT

Type 2 diabetes mellitus in adolescents has increased dramatically, with an incidence increasing from 9 to 18 cases per 100,000 per year in the last two decades. Extra Virgin Olive Oil (EVOO) has been shown to have a protective effect against diabetes through its bioactive components. This study aims to analyze the effect of EVOO supplementation on anthropometric parameters as an indicator of diabetes prevention in adolescent girls. This quasi-experimental study employed a pretest-posttest control-group design. The study population comprised all adolescent girls at SMKN 13 Malang, and subjects were selected through purposive sampling; 30 adolescent girls aged 15-18 years were included. Subjects were divided into an intervention group (n=15) who received 10ml/day of EVOO supplementation for 12 weeks and a control group (n=15) who received no treatment. The parameters measured included body weight, height, and waist circumference. The analysis used paired t-tests and Mann-Whitney tests. The results showed a significant decrease in body weight (p=0.000), BMI (p=0.000), and waist circumference (p=0.000) compared to the control group, which experienced an increase in body weight (0.5 kg) and waist circumference (0.233 cm). Still, there was no significant difference in height (p=0.539). In conclusion, EVOO supplementation is effective in reducing body weight and waist circumference in adolescent girls, demonstrating its potential as a preventive agent for diabetes mellitus through improving body composition.

Introduction

Type 2 diabetes mellitus (DM) in adolescents has become a worrying global epidemic. Recent data from the CDC indicates that cases of type 2 diabetes in adolescents are projected to increase by 700% if current trends continue. (Centers for Disease Control and Prevention, 2024). This increase is closely related to lifestyle changes, increased obesity, and unhealthy eating patterns in the adolescent population. Adolescent girls are at particular risk due to hormonal changes during puberty that can affect insulin sensitivity (Deusdará, de Moura Souza, & Szklo, 2022). Furthermore, social and cultural pressures often influence adolescent girls' eating and physical activity patterns, placing them at increased risk for metabolic disorders. (Chung & Rhie, 2022).

The pathophysiology of type 2 DM in adolescents is caused by metabolic changes during growth, especially during puberty, which naturally increase insulin resistance (Rao & Jensen, 2020). Additional risk factors, such as dietary changes with a predominance of foods high in saturated fat, sugar, and low in fiber, as well as decreased physical activity and a sedentary lifestyle, are major risk factors that can worsen this condition, leading to impaired glucose tolerance and ultimately to diabetes mellitus (Imperatore et al., 2012; Tryggestad et al., 2022). Hyperglycemia-induced diabetes mellitus can generate free radicals and impair the antioxidant defense system. Chronic hyperglycemia increases free radical production, leading to oxidative stress. One risk factor that increases the incidence of type 2 DM in adolescent girls is obesity (Kahn, 2020).

Adolescent obesity has emerged as a worldwide epidemic, with its prevalence consistently rising over the last twenty years. Currently, obesity affects approximately 2 billion individuals globally, posing a significant threat to public health, including in Indonesia. Projections indicate that by 2030, one in five women and one in seven men, amounting to over one billion people worldwide, will be living with obesity (Bjornstad et al., 2021). The global rate of obesity is notably higher among women compared to men, and the majority of individuals affected reside in developing countries. These regions face a dual burden of malnutrition and often lack adequate systems to manage obesity and its associated health impacts effectively (Chung & Rhie, 2022).

Globally, the WHO indicates a rising prevalence of obesity among adolescents. Specifically, the rate of obesity in individuals aged 15 to 19 years increased from 4% in 2000 to 18% in 2016. In Indonesia, obesity rates have more than doubled over a decade, rising from 10.5% in 2007 to 21.8% in 2018. East Java Province data shows that the incidence of obesity examined and diagnosed at community health centers at the age of >15 years is 16.25% of the total number of community health center visitors, while in Malang City, it is 15.57% (Dinas Kesehatan Provinsi Jawa Timur, 2018). Adolescent obesity affects not only physical health but also elevates the risk of developing diabetes mellitus, cardiovascular diseases, cancer, hypertension, and other metabolic and non-metabolic disorders. Furthermore, it contributes significantly to mortality, accounting for 5.87% of deaths due to cardiovascular disease and 1.84% of deaths related to diabetes and kidney disease (Purnell, 2023; WHO, 2024). In addition to these complications, diabetes mellitus can trigger problems during pregnancy. Prediabetes in women is also a risk factor for gestational diabetes, which is prone to causing pregnancy complications such as preeclampsia, premature birth, and the potential to develop type 2 diabetes mellitus even after delivery. The impact on the fetus is macrosomia, heart defects, tachypnea, hypoglycemia, and even stillbirth (Elsayed et al., 2023). An initial survey conducted at SMKN 13 Malang showed that 2 female students were diagnosed with type 2 diabetes mellitus and had received regular treatment from the local health center.

Early intervention is crucial because complications of diabetes mellitus can occur more quickly and be more severe if the disease begins at a young age. Possible interventions include anthropometric monitoring in adolescent girls, including weight, height, BMI, and waist circumference. An increase in body weight is linked to the development of insulin resistance and impaired function of pancreatic beta cells. Weight monitoring is an important indicator for early detection of diabetes risk. Although not significantly changing in the short term, height measurement is important for calculating body mass index (BMI), an indicator of nutritional status and metabolic risk. Waist circumference is measured to reflect visceral fat distribution, which is strongly correlated with insulin resistance. Previous research has shown that waist circumference is a more accurate predictor of diabetes risk than BMI in adolescents.

Extra Virgin Olive Oil (EVOO) contains bioactive compounds, including polyphenols, vitamin E, and monounsaturated fatty acids, which have antidiabetic effects. A recent meta-analysis showed that consuming 10-20 g of olive oil daily has benefits for the prevention and management of diabetes. The mechanism of action of EVOO includes increasing insulin sensitivity, reducing oxidative stress, and modulating the inflammatory response (Varzakas, 2021; Infante et al., 2023; Del Ben et al., 2020; Retnaningrum et al., 2021). These are the advantages of EVOO as an intervention for preventing diabetes mellitus. Previous research by Gamal *et al*. (2025) and Umar *et al*. (2025) proved that EVOO is effective for reducing glucose in rats with diabetes mellitus (Gamal *et al* , 2025; Umar *et al*,, 2025). The advantage of this research is that it is an initial study that specifically investigated the effects of EVOO on adolescent girls at risk of diabetes mellitus. This is a novelty developed by researchers, as it differs from other studies focused on the management of diagnosed diabetes. This study takes a primary prevention approach for high-risk groups, namely adolescent girls. This preventive focus offers the potential for early intervention, which can prevent or delay the onset of diabetes. This study proposes a practical, measurable dose of EVOO (10 ml/day) that can be integrated into daily eating patterns without drastic changes in eating habits. This approach is more realistic for long-term implementation than other complex dietary interventions. This study aims to analyze the effect of EVOO supplementation on anthropometric parameters (weight, height, BMI, and waist circumference) as indicators of diabetes mellitus prevention in adolescent girls.

Method

This research employed a quasi-experimental methodology using a pretest-posttest control-group design. The study lasted 12 weeks. The study population comprised all adolescent girls at SMKN 13 Malang, and subjects were selected through purposive sampling. The subjects were 30 female adolescents aged 15-19 years who met the inclusion criteria: physically healthy, no history of diabetes, not on a special diet, and willing to follow the study protocol. Exclusion criteria included: allergies to olive oil, taking medications that affect metabolism, and digestive disorders. Participants were randomly assigned to one of two groups: the intervention group (n=15), which received a daily supplementation of 10 ml of EVOO, and the control group (n=15), which did not receive any specific intervention.

Body weight was assessed using a digital scale calibrated to 0.1 kg, with subjects fasting and wearing minimal clothing. Height was measured with a stadiometer to 0.1 cm accuracy, with subjects standing upright and without shoes. Abdominal circumference was measured using a measuring tape at the narrowest point between the last rib and the superior iliac crest under normal expiratory conditions. The same researcher performed all measurements at consistent times (morning, fasting conditions) to minimize variation. The monitoring time details are 1x before receiving EVOO and 1x 3 months after consuming EVOO. The EVOO given to the sample of adolescent girls was Borges brand EVOO at a dose of 10 ml per day, taken at night to reduce the risk of nausea. The research team will closely monitor compliance with EVOO consumption via a WhatsApp group.

The data were processed using SPSS version 26.0. The Shapiro-Wilk test was conducted to evaluate the normality of the data, whereas the Levene test was applied to assess the homogeneity of variance. For data exhibiting normal distributions, paired t-tests were used to compare pre- and post-intervention values within groups, and independent t-tests were used to compare between-group values. When the data were not normally distributed, the Mann-Whitney test was used. The threshold for statistical significance was established at $\alpha = 0.05$. Ethical approval for this study was granted by the Research Ethics Committee STIKes Patria Husada Blitar under the reference number 06/PHB/KEPK/308/06.25 on June 2025. Furthermore, prior to their participation in the study, informed consent was obtained from all individuals involved. Data confidentiality is guaranteed in accordance with research ethics principles.

Results

All subjects (n=30) completed the study protocol without dropout. The mean age of the subjects was 16.8 ± 1.2 years, with a range of 15–18 years.

Table 1. Description of Intervention Group Research Data

Parameter	Minimum	Maximum	Mean	SD
Weight Pre (kg)	54,0	70,0	61,00	4,9281
Post Weight (kg)	54,0	68,0	59,73	4,5390
Height Pre (cm)	146	161	154,33	5,680
Height Post (cm)	146	161	154,67	5,512
BMI Pre (kg/m2)	25,08	27,34	25,50	0,57139
BMI Post (kg/m2)	23,92	26,56	24,94	0,74060
Waist circumference Pre (cm)	81,0	89,0	84,13	2,7482
Waist circumference Post (cm)	79,0	87,5	83,50	2,5635

(Primary data, 2025).

There was an average decrease in body weight of 1,27 kg, indicating positive changes after the intervention. Height did not show significant changes (mean difference of only 0.34 cm). This change is usually due to measurement variation. There was an average decrease in BMI of 0.56, consistent with weight loss. There was a mean decrease in waist circumference of 0,63 cm, indicating a reduction in abdominal fat. Based on the descriptive analysis of pre- and post-intervention data, participants' anthropometric status improved after the intervention. Average weight, BMI, and waist circumference decreased consistently, indicating a positive change in body composition. Although height did not show significant changes (in line with adult characteristics), decreases in other indicators suggest that the intervention affected weight loss and the risk of abdominal adiposity. Overall, the intervention demonstrated effectiveness in improving participants' anthropometric parameters.

In the control group, the average body weight before treatment was 61,06 kg, with a minimum of 54,0 kg and a maximum of 68,0 kg. After the observation period, the average body weight increased to 61,56 kg, with a range of 56,0–68,0 kg. There was no change in height in the control group. The BMI before treatment in the control group was 25,61 kg/m², with a range of 25,08–26,74 kg/m². After treatment, the average BMI increased to 25,83 kg/m², with a minimum of 25,08 kg/m² and a maximum of 27,21 kg/m². Increase in BMI by 0,22 kg/m². After the observation period, there was a trend towards improved nutritional status in the control group. This increase was consistent with the observed weight gain and illustrates that, without intervention, respondents remained in the overweight category, with a tendency towards increased adiposity risk.

Table 2. Description of Control Group Research Data

Parameter	Minimum	Maximum	Mean	SD
Weight Pre (kg)	54,0	68,0	61,06	4,3337
Post Weight (kg)	56,0	68,0	61,56	4,1656
Height Pre (cm)	146	164	154,33	5,551
Height Post (cm)	146	164	154,33	5,551
BMI Pre (kg/m2)	25,08	26,74	25,61	0,54992
BMI Post (kg/m2)	25,08	27,21	25,83	0,67462
Waist circumference Pre (cm)	81,0	91,0	85,13	85,13
Waist circumference Post (cm)	81,5	91,0	85,36	85,36

(Primary data, 2025).

The average waist circumference of the control group before treatment was 85,13 cm, with a range of 81,0–91,0 cm. After the observation period, the average waist circumference increased slightly to 85,36 cm, with a range of 81,5–91,0 cm. There was a slight increase of 0,23 cm in the control group's waist circumference. Although this change was not significant, an increase in waist circumference still indicates the accumulation of abdominal fat, a risk factor for metabolic syndrome if it persists. Overall, the control group showed an increasing trend in all anthropometric indicators, namely weight, BMI, and waist circumference. The absence of intervention resulted in the respondent's condition remaining the same or slightly worsening. These results confirm that positive changes did not occur naturally in the control group, allowing comparison with the treatment group to demonstrate the intervention's effectiveness.

Table 3. Bivariate Analysis

Variables	Group				P*
	Intervention		Control		
	Mean	SD	Mean	SD	
Weight Pre	61,00	4,9281	61,06	4,3337	0,000[a]
Weigh Post	59,73	4,5390	61,56	4,1656	
Height Pre	154,33	5,680	154,33	5,551	0,539[b]
Height Post	154,67	5,512	154,33	5,551	
BMI Pre	25,50	0,57139	25,61	0,54992	0,000[b]
BMI Post	24,94	0,74060	25,83	0,67462	
Waist circumference Pre (cm)	84,13	2,7482	85,13	2,9488	0,000[a]
Waist circumference Post (cm)	83,50	2,5635	85,36	2,7155	

*Statistical Test
[a]T-Test
[b]Mann Whitney
(Primary data, 2025).

The results of the normality test showed that most of the data were normally distributed (p>0.05), except for the pre-height of the intervention group (p=0.047). Therefore, the height analysis used a non-parametric test (Mann-Whitney test). All variables showed homogeneous variance between groups (p>0.05). The statistical analysis results showed a significant weight loss in the intervention group (p=0.000), while the control group experienced weight gain. No statistically significant difference in height was found between the groups (p = 0.539), as expected, given that height is relatively stable in late adolescence. Meanwhile, there was a significant decrease in waist circumference in the intervention group (p=0.000), indicating a reduction in visceral fat. No subjects reported serious side effects during the intervention period. Some subjects reported mild gastrointestinal discomfort in the first week, which subsided with adaptation. Compliance was 95% based on daily intake records.

Discussion

Weight loss (-1.267 kg) in the intervention group, a significant difference, indicates the effectiveness of EVOO supplementation in weight management. These findings are consistent with meta-analyses showing that olive oil consumption is associated with a reduced risk of obesity (Jiménez-Sánchez et al., 2022). The extreme statistical significance (p=0.000) indicates that the observed difference was not due to chance, but rather a real effect of the EVOO intervention. The underlying mechanisms include: 1. Satiation Effect: Monounsaturated fatty acids in EVOO increase the production of satiety hormones such as peptide YY and GLP-1, thereby reducing total calorie intake. 2. Thermogenesis: EVOO's polyphenolic components increase mitochondrial activity and thermogenesis, which can accelerate fat burning. 3. Lipid Metabolism Modulation: EVOO activates the AMPK pathway, which increases fatty acid oxidation and reduces fat synthesis. The molecular mechanism of EVOO involves several pathways, namely the insulin signaling pathway, in which EVOO's bioactive components increase IRS-1 (insulin receptor substrate-1) phosphorylation and activate the PI3K/Akt pathway, thereby improving glucose uptake by cells. Oxidative stress pathway, where antioxidants in EVOO reduce reactive oxygen species (ROS) that can damage pancreatic beta cells and interfere with insulin secretion. Lastly, the inflammatory pathway, so that EVOO inhibits the activation of the NF-κB pathway, which plays a role in chronic inflammation and insulin resistance (Silenzi et al., 2020; Bozzetto et al., 2016; Rodríguez et al., 2020).

A significant reduction in BMI in the intervention group (-0.56 vs +0.22 in the control, p=0.000) reflects comprehensive changes in body composition. Recent prospective cohort studies showed that a ½ tablespoon (7 g) increase in daily olive oil consumption was inversely associated with body weight. These findings indicate that EVOO not only affects body weight at the surface but also alters the ratio of fat mass to total body mass. EVOO, especially its phenols, can modulate NF-κB expression, reduce the inflammatory cascade, which plays an important role in the regulation of metabolism and energy homeostasis (Patti et al., 2020; Dehghani et al., 2021).

The decrease in waist circumference (-0.633 cm) in the intervention group indicates a reduction in visceral fat, which has important implications for diabetes prevention. Visceral fat is strongly correlated with insulin resistance and systemic inflammation. Research suggests that the polyphenols in EVOO, particularly hydroxytyrosol and oleuropein, have anti-inflammatory effects that reduce the production of pro-inflammatory cytokines from visceral adipose tissue. This reduction in inflammation improves insulin sensitivity. Although this study did not directly measure biochemical parameters of diabetes, the observed anthropometric changes suggest an improvement in the diabetes risk profile, namely: 1. Weight loss: a reduction of 1 kg in body weight corresponds to a 16% decrease in the risk of developing diabetes. 2. Reduction in visceral fat: a reduction of 1 cm in waist circumference is associated with a 5-7% reduction in diabetes risk. These findings support the concept that nutritional intervention with EVOO can be a primary strategy for diabetes prevention in high-risk populations.

The results of this study are consistent with the PREDIMED study, which demonstrated the protective effect of a Mediterranean diet rich in EVOO against diabetes (Correia et al., 2023; Salvo & Tuttolomondo, 2025; Patti et al., 2020). However, this study is the first to focus on adolescent girls, with anthropometric measurements as the primary outcome. The difference with adult studies lies in adolescents' greater responsiveness, likely due to greater metabolic plasticity in this age group. These findings have important implications for diabetes prevention programs in adolescents, namely: 1. Early intervention with EVOO supplementation can be integrated into diabetes prevention programs in schools. 2. Cost-effective strategies, namely EVOO, are relatively affordable and easily accessible compared to pharmacological interventions. 3. A holistic approach by combining nutrition education and physical activity promotion for optimal results.

Although the study results show strong statistical significance, it is important to acknowledge several limitations. The absence of significant changes in height (p=0.539) was expected, given that adult height is generally stable. The reduction in these anthropometric parameters indicates an improved diabetes mellitus risk profile and the potential of EVOO as a diabetes prevention agent in this female adolescent population. The observed changes reflect improved body composition and reduced visceral fat, which correlate with increased insulin sensitivity and a reduced risk of diabetes. The underlying mechanisms include antioxidant, anti-inflammatory, and lipid-metabolism-modulating effects of EVOO's bioactive components. This study provides evidence-based recommendations for EVOO consumption in the context of diabetes prevention in adolescents. However, longer-term studies with larger sample sizes and direct biochemical parameters are needed to confirm these findings. The results of this study formulate several recommendations, namely: Clinical Practice: Healthcare providers may recommend EVOO as part of a diabetes prevention strategy in high-risk adolescents. Further Research: Longitudinal studies with longer follow-up are needed. Health Policy: The study findings can support nutrition education programs that promote EVOO consumption in healthy adolescent diets. Implementation: EVOO supplementation can be integrated into school health programs with regular monitoring and evaluation.

Conclusions

Extra Virgin Olive Oil (EVOO) supplementation with 10 ml/day for 12 weeks has been shown to reduce body weight (p=0.000), BMI (p=0.000), and waist circumference(p=0.000) in adolescent girls.

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