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ASSOCIATIONS OF EATING BEHAVIOR, SUGAR-SWEETENED BEVERAGE INTAKE, AND PHYSICAL ACTIVITY WITH BODY MASS INDEX AND WAIST CIRCUMFERENCE

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ABSTRACT
The high prevalence of obesity in Indonesia relates to dietary shifts, yet concurrent studies on appetitive traits (AEBQ), sugar-sweetened beverage (SSB) intake, and physical activity (GPAQ) remain limited. To investigate their associations with BMI and waist circumference (WC) in adults in Surakarta. Methods: A cross-sectional study utilized consecutive sampling to include 99 adults (73.7% female, mean age 49.3 years) at three primary health centers. Data were collected through structured questionnaires and anthropometric measurements (body weight, height, and waist circumference). Multiple linear regression with bootstrap convidence intervals (1000 resamples). In the BMI model, significant positive associations were found for female sex (β=1.80; 95% CI –0.50 to 4.10; p=0.025), married (β=1.89; 95% CI –0.82 to 4.59; p=0.011), family history of obesity (β=4.41; 95% CI 0.88 to 7.93; p=0.014), moderate SSB intake (β=2.34; 95% CI 0.05 to 4.63; p=0.045), and excessive SSB intake (β=1.65; 95% CI 0.60 to 2.71; p=0.008). College education was inversely associated (β=–6.08; 95% CI –10.50 to –1.66; p=0.007). For WC, moderate (β=4.94; 95% CI 3.80 to 6.09; p<0.001) and excessive SSB intake (β=9.54; 95% CI 8.42 to 10.66; p<0.001) were the strongest predictors. Family history of obesity (β=8.75; 95% CI 0.82 to 16.68; p=0.031) and first-hand smoking (β=5.83; 95% CI 1.05 to 10.61; p=0.024) were also associated with larger WC, while intermediate (β=–20.55; 95% CI –38.32 to –2.78; p=0.023) and college education (β=–21.51; 95% CI –38.73 to –4.29; p=0.014) were protective. Physical activity and appetitive traits were not significant. High SSB consumption is independently associated with elevated BMI and central adiposity. Higher education was protective; family history of obesity and smoking increased risk.

Keywords: AEBQ; eating behavior; obesity; physical activity; sugar-sweetened beverages; waist circumference

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INTRODUCTION
The global prevalence of obesity has risen dramatically over the past three decades, affecting more than 650 million adults worldwide (WHO, 2025). Indonesia mirrors this trend: the Indonesian Basic Health Research (Riskesdas) documented an increase in central obesity from 18.8% (2007) to 31.0% (2018), with urban areas reaching 35% (Kemenkes, 2023). The 2023 Indonesian Health Survey (SKI) further reported that 47.5% of the population consumed sugar sweetened beverages (SSBs) more than once daily and nearly 37% were insufficiently active (Kemenkes, 2023).At the district level, the Surakarta City Health Profile reveals a sharp escalation in obesity cases from 3,086 in 2023 to 4,743 in 2024 and 7,260 in 2025 paralleling an increase in diabetes mellitus cases. This accelerating burden underscores the urgency of investigating modifiable risk factors such as physical inactivity and high SSB intake.

Waist circumference (WC), a marker of visceral adiposity, predicts cardiometabolic risk more accurately than body mass index (BMI) alone (Popkin and Hawkes, 2016). In Indonesia, women carry a disproportionately high risk of central obesity, with female sex conferring a more than four fold increase after adjustment (Immanuel and Charissa, 2023). Low physical activity has been identified as a key modifiable risk factor, particularly among Indonesian men (Anindya et al., 2023), and inactive individuals in the IFLS 5 cohort had a 1.049 fold higher risk of central obesity (Satyawestri et al., 2024). Meanwhile, systematic reviews and meta analyses consistently link SSB consumption to weight gain and increased WC (Neelakantan et al., 2021; Farhangi et al., 2022), though some local studies have reported non significant associations, possibly due to methodological heterogeneity (Syahfitri et al., 2024). Importantly, most prior Indonesian studies examined physical activity or SSBs in isolation, leaving a gap in understanding their joint contribution to both general and abdominal adiposity.

Beyond lifestyle behaviours, stable psychological predispositions toward food appetitive traits also drive overeating and weight gain. According to the behavioural susceptibility theory, genetic and environmental influences converge through appetitive traits that render some individuals more vulnerable to the obesogenic environment (Masood and Moorthy, 2023). The Adult Eating Behaviour Questionnaire (AEBQ) captures eight such traits: four food approach (Hunger, Food Responsiveness, Emotional Over Eating, Enjoyment of Food) and four food avoidance (Satiety Responsiveness, Emotional Under Eating, Food Fussiness, Slowness in Eating) (Hunot et al., 2016). Validated across diverse populations, the AEBQ has demonstrated consistent associations between higher BMI and elevated food approach scores and between higher BMI and diminished food avoidance scores (Hunot et al., 2016). Yet, the AEBQ has seldom been deployed in Indonesian settings. Critically, no study has simultaneously integrated appetitive traits, SSB consumption, and physical activity each measured with validated instruments to explain variance in both BMI and WC within a single Indonesian population. For SSB intake, we used an Indonesian questionnaire created by the author based on a modification of the Beverage Questionnaire-15 (BEVQ-15) (Hedrick, 2020). The questionnaire covers ten beverage types commonly consumed by residents in Surakarta city; weekly volume (ml) was derived from reported frequency and portion size, then converted into estimated daily sugar intake (g/day) using beverage-specific conversion factors (Supplementary Table S1). This gap limits the development of multi-component interventions targeting not only lifestyle behaviours but also the psychological susceptibility to overeating. Therefore, the present study aimed to analyse the associations of appetitive traits (AEBQ), daily sugar intake from SSBs, and physical activity level (GPAQ) with BMI and WC among adults in Surakarta, while adjusting for sociodemographic and lifestyle confounders.

METHOD

Study Design and Population

This cross-sectional study recruited adult visitors at three primary health care (*Puskesmas*) in Surakarta (Puskesmas Gilingan, Puskesmas Pajang, and Puskesmas Purwodiningratan) selected purposively based on high obesity case records. Data collection was conducted in May 2026. Consecutive sampling was used to recruit eligible visitors. The sample size was calculated using the Slovin formula, with an estimated average monthly population of 200 adults and a margin of error of 0.07. To account for potential incomplete data, 110 respondents were recruited. After data cleaning, 99 complete records were analyzed (effective response rate 90%).

Variables and Measurement

Dependent variables were body mass index (BMI) and waist circumference (WC), both treated as continuous outcomes. Weight was measured with a digital scale (nearest 0.1 kg) and height with a stadiometer (nearest 0.1 cm); BMI was calculated as weight (kg) divided by height squared (m^2). Waist circumference was measured at the midpoint between the lowest rib and the iliac crest during normal expiration using a non-elastic tape. For descriptive tables only, BMI was also categorized using the WHO Asian cut-offs: underweight (<18.5), normal (18.5–22.9), overweight (23–24.9), and obesity (≥25 kg/m²); WC was classified as normal (men <90 cm, women <80 cm) or central obesity (men ≥90 cm, women ≥80 cm).

Physical activity was assessed with the Global Physical Activity Questionnaire (GPAQ). Total metabolic equivalent (MET) minutes per week were computed and categorized into three levels: low (<600 MET-min/week), moderate (600–3000 MET-min/week), and vigorous (>3000 MET-min/week), following the GPAQ analysis guide.

SSB consumption was measured using an Indonesian questionnaire, which is created by the author based on modification of Beverage Questionnaire-15 (BEVQ-15) (Hedrick, 2020). It covers ten beverage types commonly consumed in Surakarta. Weekly volume (ml) was derived from reported frequency and portion size, then converted into estimated daily sugar intake (g/day) using beverage-specific conversion factors (Supplementary Table S1). Daily sugar from SSBs was categorized as normal (<25 g/day), moderate (25–50 g/day), or excessive (>50 g/day).

Appetitive traits were evaluated with the Adult Eating Behaviour Questionnaire (AEBQ). The AEBQ was translated into Indonesian through forward-backward procedures and pre-tested in a separate sample. The instrument comprises 35 items rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) and measures eight traits: four food approach (Hunger, Food Responsiveness, Emotional Over-Eating, Enjoyment of Food) and four food avoidance (Satiety Responsiveness, Emotional Under-Eating, Food Fussiness, Slowness in Eating). Subscale scores were calculated as the mean of the respective items. To integrate the eight traits into a single variable for multivariable modelling, participants were classified as having a predominant food approach profile if the average of the four approach subscale scores exceeded the average of the four avoidance subscale scores, and as food avoidance otherwise. Covariates included age (years), sex (male/female), education (incomplete primary school, primary school [SD/SMP], secondary school [SMA], college/university), marital status (unmarried/married), family history of obesity (at least one first-degree relative), and smoking status (first-hand smoker, second-hand smoker, non-exposure).

Statistical Analysis

All analyses were performed using Stata 17 (StataCorp, 2021). Descriptive statistics are presented as frequencies and percentages for categorical variables and as mean ± standard deviation (SD) for continuous variables. The Shapiro–Wilk test was used to assess normality of continuous variables; because several variables deviated from normality, Spearman correlation coefficients were computed to evaluate bivariate associations between each predictor and the two continuous outcomes (BMI and WC).

Multivariable analysis employed multiple linear regression with the enter method. Two separate models were built, with BMI and WC as the dependent variables. For each independent variable, unstandardized regression coefficients (β), 95% confidence intervals (CI), and p-value are reported. Model assumptions (normality and homoscedasticity of residuals, absence of multicollinearity) were checked using diagnostic plots and variance inflation factors (VIF); all VIF values were < 5, indicating no serious collinearity. A two-sided p-value < 0.05 was considered statistically significant. Indirect, direct, and total effect were estimated, and confidence interval were obtained using bootstrapping with 1000 resamples.

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, Universitas Sebelas Maret (No. 29/UN27.06.11/KEP/EC/2026, 13 February 2026). All participants provided written informed consent prior to data collection. Confidentiality of personal data was strictly maintained, and participation was entirely voluntary.

RESULT

Participant Characteristics

A total of 99 adults (mean age 49.3 ± 15.9 years, 73.7% female) were enrolled, with a mean BMI of 25.2 ± 4.9 kg/m² and mean waist circumference of 81.4 ± 14.3 cm. Most participants were married (80.8%), had no family history of obesity (89.9%), and were not first-hand smokers (94.9%), though 51.5% were exposed to second-hand smoke. Regarding physical activity, 47.5% had vigorous levels, 30.3% moderate, and 22.2% low. For SSB intake, 45.5% consumed excessive amounts (>50 g/day), followed by low (31.3%) and moderate (23.2%) intake. Appetitive traits were nearly evenly split between food approach (48.5%) and food avoidance (51.5%). Detailed characteristics are presented in Table 1.

Table 1.
Characteristics of Respondents (n=99)

Variable	f (%)	Mean ± SD
Age (year)		49.3 ± 15.9
Adult (19-59)	74 (74.8)	43.1 ± 13.4
Elderly (≥60)	25 (25.2)	67.5 ± 4.5
Sex		
Male	26 (26.3)	
Female	73 (73.7)	
Education		
Incomplete primary school	3 (3)	
Primary school (SD/SMP)	40 (40.4)	
Secondary school (SMA)	37 (37.4)	
College/University	19 (19.2)	
Marital status		
Unmarried	19 (19.2)	
Married	80 (80.8)	
Family history of obesity		
No	89 (89.9)	
Yes	10 (10.1)	
BMI (kg/m²)		25.2 ± 4.9
Underweight (< 18.5)	6 (6.1)	13.2 ± 1.7
Normal (18.5 – 22.9)	31 (31.3)	21.4 ± 0.9
Overweight (23 – 24.9)	15 (15.2)	23.9 ± 0.5
Obesity (≥ 25)	47 (47.4)	29.4 ± 3.3
Waist circumference (cm)		81.4 ± 14.3
Normal (male < 90; female < 80)	52 (52.5)	
Central obesity (male ≥ 90; female ≥ 80)	47 (47.5)	
Smoking status		
First hand smoker	5 (5.1)	
Second hand smoker	51 (51.5)	
Non-exposure	43 (43.4)	
Physical Activity (MET-minutes per week)		5999.2 ± 9032.5
Low (<600)	22 (22.2)	
Moderate (600-3000)	30 (30.3)	
Vigorous (>3000)	47 (47.5)	
SSB Consumption (g/day)		55.4 ± 51.9
Low (<25)	31 (31.3)	
Moderate (25-50)	23 (23.2)	
Excessive (>50)	45 (45.5)	
Appetitive traits (AEBQ)		
Food Approach	48 (48.5)	
Food Avoidance	51 (51.5)	

Normality and Reliability

Shapiro–Wilk tests indicated that BMI was normally distributed across nearly all subgroups (p > 0.05), with the exception of first-hand smokers (p = 0.005). Waist circumference, however, deviated from normality in several subgroups, including males (p = 0.020), those married (p = 0.012), those with a food avoidance profile (p = 0.042), and both second-hand smokers (p = 0.043) and unexposed individuals (p = 0.029). Because multiple subgroup distributions were non-normal, Spearman correlations were used for bivariate associations. Regarding instrument reliability, the overall Cronbach's α for the 35-item AEBQ was 0.85. The Indonesian SSB questionnaire demonstrated good internal consistency (McDonald's ω = 0.73). For the GPAQ, after standardization of the 17 activity items into z scores, Cronbach's α was 0.70. All instruments were therefore considered reliable for the present sample.

Bivariate Associations

Table 2 displays Spearman bivariate correlations between each predictor variable and both BMI and waist circumference. Female sex was significantly correlated with BMI (r = 0.257, *p* = 0.003) but not with waist circumference (r = 0.120, *p* = 0.212). Married status, family history of obesity, and higher SSB consumption were significantly correlated with both BMI and WC. Smoking status also exhibited a significant but small correlation with the two outcomes. Age, physical activity, and appetitive traits were not significantly correlated with BMI or WC. Education level was significantly inversely correlated with WC (r = –0.204, *p* = 0.036) but not with BMI (r = –0.167, *p* = 0.101).

Table 2.
Bivariate Spearman Correlations of Study Variables with BMI and Waist Circumference

Variable	BMI		WC	
	r	*p*	R	*P*
Age (year)	0.058	0.570	0.063	0.559
Sex	0.257	0.003	0.120	0.212
Education	–0.167	0.101	–0.204	0.036
Marital status	0.273	0.008	0.238	0.040
Family history of obesity	0.263	0.002	0.222	0.029
Smoking status	–0.222	0.027	0.200	0.045
Physical Activity (MET-minutes per week)	–0.020	0.846	–0.064	0.539
SSB Consumption (g/day)	0.328	0.001	0.210	0.036
Appetitive traits (AEBQ)	0.118	0.248	0.076	0.470

Multivariable Analysis

Model for Body Mass Index (Table 3)

In the multiple linear regression model for BMI, female sex (β = 1.80; 95% CI –0.50 to 4.10; p = 0.025), married status (β = 1.89; 95% CI –0.82 to 4.59; p = 0.011), family history of obesity (β = 4.41; 95% CI 0.88 to 7.93; p = 0.014), moderate SSB consumption (β = 2.34; 95% CI 0.048 to 4.632; p = 0.045), and excessive SSB consumption (β = 1.65; 95% CI 0.594 to 2.706; p = 0.008) were independently associated with higher BMI. Conversely, all education levels above incomplete primary education were significantly associated with lower BMI: primary school (β = –5.69; 95% CI –9.38 to –2.01; p = 0.002), secondary school (β = –6.39; 95% CI –10.57 to –2.20; p = 0.003), and college/university (β = –6.08; 95% CI –10.50 to –1.66; p = 0.007). Smoking status also contributed significantly, although the coefficient pattern varied across categories. Physical activity and appetitive traits were not significantly associated with BMI in this model.

Model for Waist Circumference (Table 4)

The multiple linear regression model for waist circumference identified SSB consumption as the strongest predictor. Relative to low intake, moderate intake (β = 4.94; 95% CI 3.794 to 6.086; p < 0.001) and excessive intake (β = 9.54; 95% CI 8.424 to 10.658; p < 0.001) were associated with substantially larger waist circumference. Family history of obesity (β = 8.75; 95% CI 0.82 to 16.68; p = 0.031) and first hand smoker status (β = 5.83; 95% CI 1.048 to 10.612; p = 0.024) were also independently linked to greater waist circumference. In contrast, secondary school (β = –20.55; 95% CI –38.32 to –2.78; p = 0.023) and college/university (β = –21.51; 95% CI –38.73 to –4.29; p

= 0.014) exhibited a significant protective inverse association. Sex, marital status, physical activity, and appetitive traits did not reach statistical significance in this model.

Table 3.
Multiple Linear Regression Analysis for Body Mass Index (n=99)

Variable	β	95% CI		*p*-value
		Lower	Upper	
Age (year)				
Adult (19-59)	1.146	–1.405	3.698	0.379
Elderly (≥60)	ref.	ref.	ref.	ref.
Sex				
Male	ref.	ref.	ref.	ref.
Female	1.798	–0.498	4.095	0.025
Education				
Incomplete primary school	ref.	ref.	ref.	ref.
Primary school (SD/SMP)	–5.694	–9.380	–2.008	0.002
Secondary school (SMA)	–6.388	–10.574	–2.201	0.003
College/University	–6.079	–10.503	–1.655	0.007
Marital status				
Unmarried	ref.	ref.	ref.	ref.
Married	1.885	–0.816	4.585	0.011
Family history of obesity				
No	ref.	ref.	ref.	ref.
Yes	4.409	0.884	7.933	0.014
Smoking status				
First hand smoker	–1.273	-2.164	-0.382	0.007
Second hand smoker	–0.303	-0.581	-0.025	0.030
Non-exposure	ref.	ref.	ref.	ref.
Physical Activity (MET-minutes per week)				
Low (<600)	ref.	ref.	ref.	ref.
Moderate (600-3000)	–0.894	–3.886	2.099	0.558
Vigorous (>3000)	–0.752	–3.218	1.715	0.550
SSB Consumption (g/day)				
Low (<25)	ref.	ref.	ref.	ref.
Moderate (25-50)	2.340	0.048	4.632	0.045
Excessive (>50)	1.650	0.594	2.706	0.008
Appetitive traits (AEBQ)				
Food Approach	–0.371	–2.577	1.835	0.742
Food Avoidance	ref.	ref.	ref.	ref.

β: unstandardized coefficient; SE: standar error; CI: confidence interval. CI were estimated using bootstrapping (1000 resamples)

Table 4.
Multiple Linear Regression Analysis for Waist Circumference (n=99)

Variable	β	95% CI		*p*-value
		Lower	Upper	
Age (year)				
Adult (19-59)	3.356	-3.418	10.131	0.332
Elderly (≥60)	ref.	ref.	ref.	ref.
Sex				
Male	ref.	ref.	ref.	ref.
Female	-2.183	-9.135	4.770	0.538
Education				
Incomplete primary school	ref.	ref.	ref.	ref.
Primary school (SD/SMP)	-15.763	-32.907	1.381	0.072
Secondary school (SMA)	-20.552	-38.324	-2.781	0.023
College/University	-21.510	-38.726	-4.294	0.014
Marital status				
Unmarried	ref.	ref.	ref.	ref.
Married	9.914	-0.164	19.992	0.054
Family history of obesity				
No	ref.	ref.	ref.	ref.
Yes	8.751	0.821	16.682	0.031

	β	95% CI		*p*-value
Smoking status				
First hand smoker	5.830	1.048	10.612	0.024
Second hand smoker	1.016	-7.204	9.236	0.766
Non exposure	ref.	ref.	ref.	ref.
Physical Activity (MET-minutes per week)				
Low (<600)	ref.	ref.	ref.	ref.
Moderate (600-3000)	-1.923	-10.150	6.304	0.647
Vigorous (>3000)	-4.411	-10.479	1.657	0.154
SSB Consumption (g/day)				
Low (<25)	ref.	ref.	ref.	ref.
Moderate (25-50)	4.940	3.794	6.086	<0.001
Excessive (>50)	9.541	8.424	10.658	<0.001
Appetitive traits (AEBQ)				
Food Approach	1.26	-5.48	8.01	0.713
Food Avoidance	ref.	ref.	ref.	ref.

β: unstandardized coefficient; SE: standar error; CI: confidence interval. CI were estimated using bootstrapping (1000 resamples)

DISCUSSION

This study examined associations of appetitive traits, sugar-sweetened beverage (SSB) intake, and physical activity with BMI and waist circumference (WC) in adults from Surakarta, Indonesia. Our primary finding is that SSB consumption was the strongest independent correlate of both general and central adiposity, with a clear dose-response relationship. Compared to low intake (<25 g/day), moderate (25–50 g/day) and excessive (>50 g/day) SSB intake were associated with significantly higher BMI and, more notably, with substantially larger WC (excessive: β = 9.54 cm, 95% CI 8.42–10.66, p < 0.001). A 9.5 cm increase in WC is clinically meaningful, corresponding to a marked increase in cardiometabolic risk (Rubino *et al.*, 2025).

The strong SSB–WC link is mechanistically plausible. Fructose, the primary sweetener in SSBs, is metabolized almost exclusively in the liver. Unlike glucose, fructose phosphorylation by ketohexokinase (KHK) is not feedback-inhibited, leading to unopposed generation of substrates for *de novo* lipogenesis (DNL) (Hermann *et al.*, 2011; Herman and Birnbaum, 2022). DNL produces fatty acids that are esterified into triglycerides and packaged into VLDL, which are preferentially stored in visceral adipose tissue (Taskinen *et al.*, 2019). Moreover, the combination of fructose and glucose synergistically activates the transcription factors ChREBP and SREBP-1c, upregulating the entire lipogenic enzyme cascade (Geidl-flueck *et al.*, 2021). Our dose-response finding moderate intake already significantly increased WC supports the WHO recommendation to limit free sugars to <10% of total energy.

Higher education emerged as a strong protective factor. Participants with secondary school (SMA) or college had a WC approximately 20–21 cm lower than those with incomplete primary education. This finding appears to contrast with a national Indonesian study reporting that overweight/obesity is more concentrated among the more educated (Nurokhmah, 2025). However, the discrepancy is likely explained by differences in sample characteristics: our sample was predominantly older (mean age 49 years), urban-dwelling, and female (73.7%). Among older urban adults, higher education is associated with better health literacy and more effective weight management, including lower SSB intake. This highlights subnational heterogeneity, which is important for targeted interventions.

Physical activity was not significantly associated with BMI or WC. This null finding may reflect limited variability (only 22.2% were inactive), the predominantly female sample (previous studies show weaker activity-adiposity associations in women), and compensatory behaviours such as reduced non-exercise activity thermogenesis (NEAT) or increased post-exercise energy intake (Loeffelholz, 2022). Similar null findings have been reported among university students in Malang

(Rahmawati *et al.*, 2025). Thus, in this population, dietary factors especially SSB intake appear more influential than physical activity in determining body composition. Appetitive traits, operationalized as a binary food-approach vs. food-avoidance profile, showed no significant associations. This is likely due to information loss from dichotomization; previous AEBQ studies show that continuous subscales (e.g., Enjoyment of Food, Satiety Responsiveness) are more sensitive to weight status (Hunot *et al.*, 2016). Future studies in Indonesia should use continuous AEBQ scores.

Family history of obesity was a strong predictor of higher BMI ($\beta = 4.41$, $p = 0.014$) and larger WC ($\beta = 8.75$, $p = 0.031$), consistent with heritability estimates (40–70%). First-hand smoking independently predicted larger WC ($\beta = 5.83$, $p = 0.024$), aligning with Mendelian randomization evidence that smoking causally increases visceral fat (Carrasquilla and Kilpeläinen, 2024). Of note, first-hand smokers had a slightly lower BMI ($\beta = -1.27$, 95% CI –2.16 to –0.38, $p = 0.007$) yet a significantly larger waist circumference ($\beta = 5.83$, 95% CI 1.05 to 10.61, $p = 0.024$). This discordant pattern is biologically plausible: nicotine increases metabolic rate and suppresses appetite, reducing overall weight, while simultaneously promoting visceral fat accumulation through insulin resistance and nicotinic receptor-mediated lipolysis (Carrasquilla and Kilpeläinen, 2024). Consequently, waist circumference better reflects the metabolic risk of smoking, confirming that smoking increases central adiposity despite a lower BMI. Notably, the mechanism does not involve cortisol or sex hormones but may involve nicotinic receptor-mediated lipolysis.

Implications

Reducing SSB consumption should be the top priority for obesity prevention in urban Indonesia. Population-level interventions such as SSB excise taxes, front-of-pack warning labels, and restrictions on SSB advertising are urgently needed. Smoking cessation programs should be integrated into obesity prevention efforts. While physical activity promotion remains important for overall health, it should not substitute for dietary sugar reduction.

Limitations

The cross-sectional design precludes causal inference. The modest sample size (n=99) limits statistical power, particularly for detecting small effects of physical activity and appetitive traits. The sample was predominantly female and older, limiting generalizability. The binary operationalization of AEBQ was suboptimal. Residual confounding cannot be excluded.

CONCLUSION

High SSB consumption is the dominant modifiable correlate of both general and central adiposity in Surakarta adults. Higher education is protective in this urban older population, while family history of obesity and first hand smoking increase risk. Physical activity and appetitive traits (as binary) showed no independent associations. Immediate public health actions SSB taxation, warning labels, and targeted nutrition education are urgently needed.

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