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Research Article

Underreported Energy Intake Methods with Metabolic Risk Outcomes among Overweight and Obese Teachers in East Coast, Malaysia

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ABSTRACT

This study compares three methods of detecting EI (Energy Intake) underreporting and examines their associations with body composition measures—such as Body Mass Index (BMI), body fat percentage, and muscle mass—as well as blood test results, including fasting blood sugar and lipid profiles among overweight and obese adults in East Coast, Malaysia. A total of 333 secondary school teachers, aged 20 to 60 years, were recruited using multistage sampling for this cross-sectional study. We collected sociodemographic characteristics, anthropometric measurements, blood pressure, and biochemical parameters using standardized and validated instruments. Dietary intake data were obtained using validated semi-quantitative Food Frequency Questionnaire (FFQ). Underreporting was assessed using the revised-Goldberg method (EI/ Basal Metabolic Rate (BMR) ratio of 1.2 and 0.9, based on the Mifflin-St Jeor equation) and the EI sex-specific <2.5th and >97.5th percentile. The majority of participants were Malay (98.8%), with a mean age of 48.85±6.88 years old. On average, they were classified as overweight (BMI: 29.30±3.74 kg/m²) and had a high waist circumference (91.66±10.40 cm). The discrepancy between the Goldberg EI/BMR<1.2 and EI sex-specific<2.5th and >97.5th percentile method (26.1% vs. 4.8% underreporters) reflects the higher sensitivity but lower specificity of the Goldberg method, which may have led to higher underreporting estimates to the EI sex-specific<2.5th and >97.5th percentile approach. There were significant association ($p<0.05$) between energy intake and body fat percentages, visceral fat and High-Density Lipoprotein Cholesterol (HDL-C) for all three EI underreporting methods. Meanwhile, there was significant association ($p<0.005$) between energy intake and diastolic blood pressure using EI sex-specific percentile. The EI sex-specific <2.5th and >97.5th percentile method shows promising for detecting EI misreporting in overweight and obese adults. However, further research is needed to validate these findings, as the method remains underexplored.

INTRODUCTION

Self-reported Energy Intake (EI) in dietary studies is frequently underreported, leading to information bias in dietary assessment (Suissa *et al.* 2019). While advancements in technology, such as digital photography methods, have improved automatic food recognition and portion size estimation, however dietary assessments still largely depend on self-reported methods, including Food Frequency Questionnaires (FFQ), 24-hour diet recalls (24hR), and food diaries (Dao *et al.* 2019; Höchsmann & Martin 2020). Among these, 24hR is the most commonly used method for dietary assessment in Southeast Asian countries (Arifin *et al.* 2024). However, FFQ have acceptable reproducibility and have been widely used to assess nutrient intakes across populations for epidemiological study and to assess the degree of association with disease patterns such as chronic and non-communicable diseases (Vijay *et al.* 2020).

Underreporting of EI arises from methodological biases—such as lack of standardised approach—and respondent biases, including overlooked food items and inaccurate portion size estimations (Gibson *et al.* 2017). In obese individuals, EI underreporting is strongly associated with energy expenditure measurement, highlighting the need of to include the calculation of energy intake for internal validation in dietary assessments (Black 2000). Additionally, misreporting bias may be influenced by both interviewer and respondent factors. Respondents may underreport food intakes if they perceive that lower reports could lead to food or financial aid, while interviewers may introduce bias through leading questions or judgmental remarks (Gibson *et al.* 2017). Qualitative studies have also found that overweight and obese adults express concern that the dietary data collection may lead to external judgment or increased self-awareness about their food choices and weight (Howes *et al.* 2024). Addressing these biases is crucial in population-based dietary studies to ensure reported EI is reliable (Suissa *et al.* 2019; Zainuddin *et al.* 2019).

Several participant characteristics are associated with EI underreporting, including BMI, age, gender, education level, and geographical location (Zainuddin *et al.* 2019). A higher BMI (>25 kg/m²) more than doubles the likelihood of reporting implausible EI compared to individuals with a BMI≤25, even after adjusting for gender and age (Horner *et al.* 2002). Women are more likely than men to underreport, while age alone is not a significant predictor even after adjusting for other variables (Smith *et al.* 1994). Among Latinos populations, BMI, physical inactivity, and unemployment have been identified as significant factors influencing the EI-to-BMR ratio (Olendzki *et al.* 2008).

Underreporting can distort dietary conclusions and lead to inaccurate inferences. It can also influence on nutrient estimation and impact the observed relationships between EI and anthropometry (Bailey *et al.* 2007). Excluding under-reporters in Greece resulted significant variations in micronutrient densities due to higher nutrient-to-energy ratios (Gnardellis *et al.* 1998). Additionally, underreporting has been shown to contribute to the underestimation of dietary surveillance data (Gibbons *et al.* 2014).

The Goldberg method remains the predominant approach for assessing EI misreporting, comparing reported EI to estimated energy requirements (EFSA/EU 2013). This method helps identify underreporting at the population level and evaluates variations in the EI-to-BMR (Energy Intake-Basal Metabolic Rate) ratio based on Physical Activity Levels (PAL) and cut off values may be assigned to low, medium or high (Black 2000; Tooze *et al.* 2012). However, the original Goldberg method, which relies on the Schofield equation to estimate BMR, has been found to misestimate the BMR in obese populations (Horgan & Stubbs 2003). The Total Energy Expenditure (TEE) equation, measured using the DLW method, is considered the most accurate validation technique for energy expenditure under free-living conditions. However, its high cost limits its use in large-scale studies (Livingstone 1994; Livingstone & Black 2003; IAEA 2009; Burrows *et al.* 2019; Gibson *et al.* 2017). Numerous studies in Asian and non-Asian countries suggest that using alternative underreporting EI method. In Malaysia, studies by Karupaiah *et al.* (2019) and Zainuddin *et al.* (2019) applied similar formula of Goldberg EI/BMR but using different cut-offs points of <1.2 and <0.9, respectively, to improves the sensitivity in detecting under-reporting of EI. Meanwhile, another method which determined the misreporters by using Energy Intake (EI) and gender-specific which exclude based on EI below of 2.45th and above 97.5th percentile. This method was found to be used in study by Konstantinova *et al.* (2008) in Russia, Fakhruddin *et al.* (2016) in Malaysia, and Li *et al.* (2022) in China used EI sex-specific cut-off 2.5th and 97.5th percentile of reported EI to identify misreporters. In addition, this method able to detects outliers based on the distribution of reported EI within sex groups, regardless of estimated BMR or PAL.

This study hypothesizes that different EI underreporting cut-offs impacts on metabolic risk outcomes in the overweight and obese population. This study aimed (1) determine the percentage of underreporting of EI using Goldberg method (cut-off<1.2 and <0.9, respectively) and EI sex-specific cut-off 2.5th and 97.5th percentile and (2) examine their relationship between energy intake with body composition and biochemical outcomes representing hyperglicemia and dyslipidemia.

METHODS

Design, location, and time

This cross-sectional study was conducted between October 2023 to April 2024. The study was carried out at the secondary school in Kelantan, East Coast, Malaysia. All participants provided written informed consent, and ethical approval was granted by the Research Ethics Committee (human studies) of Universiti Sains Malaysia (USM/JEPeM/22120766).

Sampling

A multistage sampling method was used. Fifteen secondary schools in Kota Bharu were chosen randomly from 49 schools located inKota Bharu district, based on the list of schools from Ministry of Education, Malaysia, and eligble individuals were then selected using purposive sampling. The sample size was determined using Cochran's (1963) one-proportion formula, $n=[(z\ \alpha/2)^2\ p\ (1–p)]/\Delta^2$, with a proportion (p) value of 29.9% based on prevalence of metabolic syndrome among teachers in Melaka, Malaysia (Lee *et al.* 2017), accounting for a 10% dropout rate.

A total of 333 participants were recruited using simple random sampling, consisting of secondary school teachers in Kota Bharu, Kelantan, aged 20–60 years old, with a BMI range of 23.0–39.9 kg/m^2. Exclusion criteria included morbid obesity (BMI>40 kg/m^2), pregnancy, breastfeeding, and employment as trainee, substitute or part-timer teachers.

Data collection

After ethical approval was granted, the data collection process initiated. Teachers received the recruitment link via WhatsApp. Participants who fulfilled the eligibility criteria may receive an information sheet. Participants signed and returned the consent form given to indicate their agreement to participate. A structured questionnaire was administered to collect sociodemographic data and study measurements. Body weight, body fat percentage, muscle mass percentage, and visceral fat were measured using digital weighing scale (OMRON Corp., Japan). Height was measured with a stadiometer (SECA, Hamburg, Germany), while Waist Circumferences (WC) and Hip Circumferences (HC) were taken using a measuring tape (Lufkin, USA). BMI classifications for Asian population followed WHO (2000) criteria, with values between 23.0–24.9 kg/m² indicating overweight and 25–40 kg/m² classified as obesity.

Blood pressure was measured using a digital sphygmomanometer (OMRON Corp., Japan) on the right upper limb while the participant was seated. All measurements were recorded twice, with the average value used for analysis. Blood samples were collected by trained phlebotomists and transferred into labelled tubes laboratory analysis. Approximately 5 mL of blood sample was drawn into Serum Separator Tube (SST) for lipid profiling, which includes Triglycerides (TG), Total Cholesterol (T-Chol), High-Density Lipoprotein-Cholesterol (HDL-C), Low-Density Lipoprotein-Cholesterol (LDL-C). Fasting Plasma Glucose (FPG) was measured using blood collected in fluoride oxalate tube. Participants were reminded about the overnight fasting for a minimum 10 hour fasting before blood sample collection. Samples were transported to the laboratory in an icebox to maintain stability before analysis.

Dietary intake was assessed using validated semi-quantitative FFQ adapted from the Malaysian Adult Nutrition Survey (IPH 2014). The participants of the study were asked about the frequency of consumption of certain portions of each food items during the last months. The questionnaire covered 164 food items categorized into 14 food groups. Participants provided information on consumption frequency (daily, weekly, or monthly), serving sizes (cups, slices, pieces, spoons, etc.), and the number of servings per intake. Serving sizes were converted into grams based on the 'Nutrient Composition of Malaysian Foods and Atlas of Food Exchanges & Portion Sizes' (Shahar *et al.* 2021). Daily food intake was analysed using Nutritionist Pro to estimate nutrient intakes.

Data analysis

Statistical analysis was conducted using Statistical Package for the Social Sciences (SPSS) version 26.0. Prior to data analysis, the normality distribution using Kolmogorov-smirnov was checked to perform statistical analysis. Under and overreporting data is defined bias subjects reporting consumption of food items in dietary intake measurements (Johansson *et al.* 1998). To identify underreported and overreported dietary data using revised-Goldberg method with an EI/BMR ratio of less than 1.2 (Goldberg *et al.* 1991) and less than 0.9 (Karupaiah *et al.* 2019), and the EI sex-specific<2.5th and >97.5th percentile cut-off method (Li *et al.* 2022). BMR was calculated based on height, weight, age, and gender using the Mifflin-St Jeor equation, which is recommended for obese adults (Frankenfield *et al.* 2005). Continuous variables were presented as mean±Standard Deviation (SD). Categorical data were reported as frequencies and percentages. Mann-Whitney U tests and Kruskal-Wallis H tests were used to examine significant differences between groups and potential cofounding factors, including age, gender, educational level, household income, and smoking status.

RESULTS AND DISCUSSION

Background of participants

Based on Table 1 total of 343 respondents were eligible to participate in this study and returned the questionnaire. However, 10 participants with not meeting the study's inclusion criteria data were excluded. Therefore, a final sample of 333 secondary school teachers from fifteen selected schools in Kelantan participated in this study was included in the analysis. The mean age of the participants was 48.85±6.88 (27.00–60.00) years old, with women making up 74.5% of the sample. The higher proportion of female participants in this study may be attributed to the larger female demographic within the Malaysian population. A similar trend was observed in previous study by Lee *et al.* (2017) among Malaysian teachers, where the majority of participants were female, with a mean age of 42.5 years old. This study population was predominantly Malay ethnicity (98.8%). Higher mean working hours per day secondary school teachers are range 7.86±0.93 hours. The majority (88.9%) held at least a degree level qualification and a small proportion of them have diploma education.

On average, participants were classified as overweight, with a mean of 29.30±3.74 kg/m^2 (23.00–39.40 kg/m^2). They also had high waist circumference 91.66±10.40 cm (67.50–126.50 cm), waist-to-hip ratio 0.88±0.09 cm (0.69–1.72), body fat percentage 35.25±5.37% (11.9–45.3%), and visceral fat levels 14.05±5.93 (6.00–30.0).

Table 1. General characteristics of study participants

Characteristics (n=333)	Value
Age (years)[1]	48.85±6.88 (27.00–60.00)
Gender[2]	
Male	85 (25.5)
Female	248 (74.5)
Ethnicity[2]	
Malay	329 (98.8)
Others	4 (1.2)
Marital status[2]	
Single	9 (2.7)
Married	312 (93.7)
Divorced	4 (1.2)
Widowed	8 (2.4)
Working hours per day[1]	7.86±0.93 (2.00–12.00)
Educational level[2]	
Diploma	3 (0.9)
Degree	296 (88.9)
Master	33 (9.9)
PhD	1 (0.3)
Monthly household income[2,*]	
B40	17 (5.3)
M40	67 (21.1)
T20	232 (73.2)
BMI (kg/m^2)[1,a]	29.30±3.74 (23.00–39.40)
WC (cm)[1,b]	91.66±10.40 (67.50–126.50)
WHR (cm)[1,c]	0.88±0.09 (0.69–1.72)
Body fat (%)[1,d]	35.25±5.37 (11.90–45.30)
Visceral fat[1,e]	14.05±5.93 (6.00–30.00)
Muscle mass (%)[1,f]	25.05±3.69 (19.20–38.90)
FPG (mmol/L)[1,g]	5.65±1.57 (4.00–18.50)
TC (mmol/L)[1,h]	5.57±1.09 (3.00–10.10)
HDL-C (mmol/L)[1,i]	1.36±0.29 (0.57–2.31)
LDL-C (mmol/L)[1,j]	3.59±1.00 (0.90–8.00)
TG (mmol/L)[1,k]	1.36±0.57 (0.50–4.40)
SBP (mmHg)[1,l]	126.50±17.07 (91.00–185.50)
DBP (mmHg)[1,m]	82.43±10.14 (60.50–121.50)

BMI: Body Mass Index; WC: Waist Circumference; WHR: Waist-to-Hip Ratio; FPG: Fasting Plasma Glucose; TC: Total Cholestrol; HDL-C: High-Density Lipoprotein Cholesterol; LDL-C: Low-Density Lipoprotein Cholesterol; TG: Triglycerides; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; [1]: Mean±SD (Min–Max); [2]: Frequency (%); [*]: Department of Statistics, Malaysia (2019): B40: Income less than RM3,899 (USD883.28); M40: Income range RM3,900 to RM6,619 (USD883.50 to USD1,499.46); T20: Income more than RM6,620 (USD1,499.69); [a]: Normal status 18.5–22.9 km^2 (WHO 2000); [b]: Normal status Men ≥90, Women ≥80 (WHO 2008); [c]: Normal status Men 0.89, Women 0.82 (Cheng *et al.* 2010); [d]: Normal status Men 10.0–19.9, Women 20.0–29.9; [e]: Normal status ≤9; [f]: Normal status: Men 32.9–35.7, Women 25.9–27.9; [g]: Normal status <5.55; [h]: Normal status <5.2; [i]: Normal status Men ≥1.04, Women ≥1.30; [j]: Normal status <2.6; [k]: Normal status <1.7 ; [l]: Normal status <130; [m]: Normal status <85; [def]: BIA obtained from Omron HBF-214 Body Composition Monitor; [ghijklm]: Standard values provided by Alberti *et al.* (2009) and a certified private Pathology & Clinical Laboratory (M) Sdn. Bhd in Malaysia

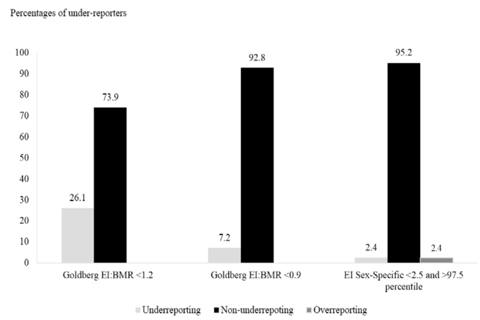
The findings of this study indicate that secondary school teachers face nutritional challenges, particularly in relation to being overweight and experiencing central obesity. According to the National Health and Morbidity Survey (NHMS) 2019, 50.1% of Malaysian adults aged 18 and above were classified as overweight or obese (IPH 2020).

Percentages of underreporting EI

Figure 1 illustrates the distribution of participants based on different methods of identifying underreporting. The majority of participants fell within the non-underreporting (normal) category. Underreporting was identified in 26.1% of participants using the Goldberg EI/BMR<1.2 method, a higher proportion compared to Goldberg EI/BMR<0.9 (7.2%). Using the EI sex-specific<2.5th and >97.5th percentile method, only 4.8% of participants were classified as Under-Reporters (UR) and Over-Reporters (OR). These results suggest that the Goldberg method may potentially overestimate the proportion of under reporters, compared to the EI percentile method because the Goldberg method compares reported EI to estimated Basal Metabolic Rate (BMR) using fixed cut-off values, which may not adequately account for individual variation in energy needs. In contrast, the percentile method is based on the distribution of reported EI within the sample based on gender and may offer context-specific classification.

In Malaysia, various studies have employed different methods to assess underreporting of EI among different population groups. For instance, Zainuddin *et al.* (2019) used the Goldberg EI/BMR method with a cut-off of <1.2 among adult population (n=9,624), while Karupaiah *et al.* (2019) utilized a cut-off of <0.9 in a multi-ethnic urban population (n=577). However, study conducted among older adults across several states (Kelantan, Selangor, Perak, and Johor) in Malaysia (n=2,322) which aim to compare nutrient intake and its adequacy in relation to cognition and successful aging were using EI sex-specific percentiles (2.5th and 97.5th) derived from the data (Fakhruddin *et al.* 2016).

Study from other countries also employed different methods to exclude participants with underreporting of EI. In Korea, Kye *et al.* (2014) they identified UR among obese adults (n=15,133) using the Goldberg EI/BMR<0.9 method. Meanwhile, in the UK, Wassan *et al.* (2012) estimated UR among Iraqi adults, male (n=28,16), using the Goldberg EI/BMR



EI: Energy Intake; BMR: Basal Metabolic Rates

Figure 1. Under reporters according to underreported EI methods

method with the Schofield BMR equation which also include both obese and normal-weight individuals. However, they applied different cut-off values: UR was defined as EI/BMR<1.14 based on Goldberg *et at.*(1991), and OR as >2.4 based on the maximum energy intake recommended by FAO/WHO/UNU (2004) for Middle Eastern population. Conversely, Orcholski *et al.* (2015) in South Africa (n=324) utilized the DLW method to identify UR, which is considered the gold standard but remains impractical for large sample sizes. The variation in underreporting assessment method and cut-off point across studies is likely influenced by differences in sample size, population characteristic, study objective, and methodology. These methodological differences highlight the need for standardized approaches to improve accuracy of data interpretation.

Nutrient intake after excluding underreporters

Table 2 presents the descriptive of nutrient intake after excluding under-reporters identified using different EI underreporting methods. The nutrient intake profile before and after excluding participants were identified using the Goldberg EI/BMR cut-off ratios of 1.2 and 0.9 reported high to low intakes of protein (101–92 g), carbohydrates (389–352 g), fat (72–65 g), and overall EI (2,628 –2,379 kcal). Meanwhile those classified by the EI sex-specific <2.5th and >97.5th percentile reported lower mean nutrient intakes of protein (101 g), carbohydrates (346 g), fat (63 g), and overall EI (2,324 kcal). Underreporting the EI method affects the accuracy of dietary intake assessments which leads to discrepancies in macronutrient and micronutrient estimations. The Goldberg EI/BMR<0.9 and EI sex-specific <2.5th and >97.5th percentile method had a lower dropout or exclusion rate in terms of nutrient intake compared to those identified using the Goldberg EI/BMR<1.2 method. The Goldberg EI/BMR<1.2 method showed greater sensitivity in detecting underreporting and improved dietary intake accuracy but resulted in a higher exclusion rate, potentially affecting sample representativeness and statistical power. Conversely, the Goldberg EI/BMR<0.9 and the EI sex-specific<2.5th and >97.5th percentile methods had lower exclusion rates, reflecting a more conservative approach that may retain some degree of underreporting.

The impact of underreporting on nutrient intake extends beyond macronutrients to micronutrients as well. A study among adults in Korea examining the effects of EI underreporting using an EI/BMR cut-off <0.9 found that UR exhibited significantly lower intake of essential micronutrients compared to non-UR, influencing dietary adequacy assessments (Kye *et al.* 2014). A dietary study involving older Australian adults using four-day weighed food diaries revealed that UR consistently recorded lower daily intakes of all macronutrients, including protein, carbohydrates, and fats, reflecting a systematic reporting bias (Govindaraju *et al.* 2021).

Significance correlation body composition and biochemical profiles with energy intake based on EI underreporting methods

Table 3 showed significant correlation ($p<0.05$) of body composition and biochemical markers UR vs non-UR based on underreported EI methods. This analysis was performed using Spearman Correlation test which to identify the metabolic risk outcomes (Body composition and biochemical profiles) with energy intake based on three underreported EI method. There was significant correlation ($p<0.05$) were found

Table 2. Descriptive of nutrients intake after excluding under-reporters based on different EI underreporting methods

Nutrients intake*	Non-excluded (n=333)	Underreporting EI methods		
		Goldberg EI/BMR <1.2 (n=246)	Goldberg EI/BMR <0.9 (n=309)	EI Sex-specific Percentile (n=317)
Macronutrients				
Energy (kcal)	2,288±89	2,628±1,040	2,379±1,064	2,324±955
Protein (g)	89±44	101±43	92±43	90±40
Carbohydrate (g)	339±165	389±159	352±161	346±150
Fat (g)	62±37	72±37	65±37	63±31
Cholesterol (mg)	386±315	441±337	398±320	398±328
Saturated fat (g)	11.6±12.1	13.5±13.3	12.1±12.4	11.4±7.9
Monosaturated fat (g)	10.9±8.2	12.6±8.7	11.4±8.3	10.8±6.4
Polyunsaturated fat (g)	6.6±4.6	7.6±4.8	6.9±4.6	6.6±3.8
Fiber (g)	9.0±8.5	10.4±9.2	9.3±8.7	0.1±8.1
Sugar (g)	75±60	88±64	78±61	74±48
Micronutrients				
Vitamin A (RE)	1,236±957	1,439±1,012	1,289±966	1,320±1,040
Vitamin C (mg)	192±188	222±202	200±190	195±190
Vitamin D (mcg)	0.07±0.29	0.09±0.33	0.08±0.30	0.06±0.12
Vitamin E (mg)	4.3±3.2	4.9±3.4	4.5±3.2	4.3±2.9
Thiamin (mg)	1.4±1.0	1.6±1.0	1.4±1.0	1.5±1.1
Riboflavin (mg)	1.9±1.3	2.3±1.4	2.0±1.3	2.0±1.3
Niacin (mg)	18±10	21±10	19±10	19±9
Vitamin B6 (mg)	1.5±1.0	1.8±1.0	1.6±1.0	1.6±1.0
Vitamin B12 (mcg)	3.8±4.3	4.4±4.7	3.9±4.4	4.1±4.9
Vitamin K (mcg)	198±266	227±294	209±272	218±280
Sodium (mg)	2,872±1,638	3,279±1,654	2,989±1,624	2,934±1,502
Calcium (mg)	670±448	776±466	696±451	675±348
Iron (mg)	19.6±10.7	22.6±10.6	20.4±10.6	20.0±10.5

*: All nutrient intakes are absolute amounts expressed as Mean±SD per day; RE: Retinol Equivalent; EI: Energy Intake; BMR: Basal Metabolic Rate

between body fat percentages, visceral fat and HDL-c with energy intake for all underreporting EI methods. However, energy intake and diastolic blood pressure showed significant correlation ($p<0.05$) when using underreporting EI sex-specific<2.5th and >97.5th percentile. These findings suggest a potential metabolic link between the accuracy of dietary intake reporting and lipid profile variations. Self-reported EI is associated with lower and extreme reported each metabolic risk parameters. In alignment with these findings, the present study demonstrated that underreported EI by UR and OR using sex-specific<2.5th and >97.5th percentiles method showed more higher correlation EI in most of body composition and biochemical profile in the opposed to other underreporting EI methods.

The percentile-based approach employed in the study by Konstantinova *et al.* (2008) among middle-aged and elderly, excluded participants whose EI fell below the 2.5th percentile or above the 97.5th percentile to examine dietary factors influencing plasma choline and betaine levels in middle-aged and elderly individuals. A similar methodology was applied in a study by Li *et al.* (2022)which excluded 191 implausible EI reports among Japanese government employees aged 30–59 years using the sex-specific 2.5th and 97.5th percentiles. Likewise, research by Fakhruddin *et al.* (2016) among Malaysian older adults also utilized the percentile-based approach to identify under- and overreporting in EI data. Implementing an appropriate cut-off for EI misreporting is crucial for ensuring the accuracy of dietary assessments and reducing bias in data collection and analysis. The percentile-based method has proven effective in distinguishing between valid and implausible EI reports while revealing significant differences in dietary intake and associated metabolic risk outcomes. However, as this approach remains relatively underexplored, further research is needed to validate its application across diverse populations and dietary assessment methods.

Strengths and limitations

A key strength of this study is its ability to compare the revised-Goldberg method using Mifflin-St Jeor equation with the EI sex-specific percentile approach in an overweight and obese population. This study utilized simple random sampling to ensure each schools has an equal chance of being selected and minimizing selections bias. The findings contribute to further research on obese individuals from diverse demographic and geographic backgrounds, using selected underreporting classification methods. Additionally, this study lays the groundwork for future investigations into the impact of dietary underreporting on longevity-related metabolic risk outcomes, such as metabolic syndrome, cardiovascular diseases, and type 2 diabetes.

However, a limitation of this study is the reliance on a single dietary assessment tool, which may restrict the generalizability of the results to other dietary evaluation methods. Another limitation that it focuses on the majority of Malay ethnicity located in the East Coast region.

Table 3. Significant correlation of body composition and biochemical markers with energy intake based on underreported EI methods

Variables	Non-excluded (n=333)	Underreporting EI methods		
		Goldberg EI/BMR <1.2 (n=246)	Goldberg EI/BMR <0.9 (n=309)	EI sex-specific percentile (n=317)
		Correlation coefficient (r) with energy intake		
Body fat (%)	-0.118*	-0.096	-0.127*	-0.118*
Visceral fat	0.192**	0.300**	0.246**	0.191**
Muscle mass (%)	0.086	0.041	0.079	0.088
FPG	0.002	0.115	0.048	0.024
TC	-0.010	-0.037	-0.055	0.010
HDL-C	-0.123*	-0.128*	-0.126*	-0.115*
LDL-C	0.001	-0.017	-0.034	0.028
TG	0.071	0.077	0.072	0.102
SBP	0.013	-0.023	0.016	0.031
DBP	0.107	0.054	0.086	0.134*

FPG: Fasting Plasma Glucose; TC: Total Cholesterol; HDL-C: High-Density Lipoprotein Cholesterol; LDL-C: Low-Density Lipoprotein Cholesterol; TG: Triglycerides; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; *$p<0.05$ and **$p<0.01$ significant using Spearman correlation test

Nonetheless, all research data were analyzed using appropriate statistical tests, ensuring the robustness of the findings. This study specifically focused on overweight and obese individuals, highlighting the importance of accurate EI assessment in this population.

CONCLUSION

A higher proportion of overweight or obese individuals were classified as under-reporters using the Goldberg EI/BMR<1.2 method. The Goldberg EI/BMR<0.9 and EI sex-specific<2.5th and >97.5th percentile method reported a lower exclusion rate in terms of nutrient intake compared to the Goldberg EI/BMR<1.2 method. An exclusion underreporting EI with consider over-reporters and sex-specific significantly influences various health parameters among overweight and obese adults. The EI sex-specific<2.5th and >97.5th percentile method showed potential for detecting EI misreporting. Future research should explore in larger free-living population and adjusted the psychological factors contributing to underreporting to validate these findings further.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

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